SCIENCE

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THE REGULATION OF NEUTRALITY IN THE ANIMAL BODY[1]

IT was a favorite figure of Cuvier's, recurring again and again in his works,[2] to compare life with a vortex into which molecules continually enter, from which they continually depart; meantime the vortex remains, and thus the form of a living thing appears to be more important than the substance. Cuvier's analogy, though almost forgotten, is quite as valid to-day as a century ago, but I suspect that the modern physiologist will be disposed to see in such a view a justification of the study of *conditions* rather than a claim for morphology. What, indeed, is the importance of the anatomy of a whirlpool in comparison with the dynamics thereof?

Now it is the study of conditions within the organism which physical chemistry has contributed to physiology—solution, surface tension, the colloidal state, osmotic pressure, ionization, alkalinity or neutrality—and these are dynamical equilibria rather than in any sense morphological elements. To such conditions Cuvier's figure exactly applies, and provides, moreover, the very best means for their systematic investigation; while the conditions, in turn, most fully reveal that which was partly made clear to Cuvier by the imagination of genius, and, in spite of it, quite certainly in part unknown to him.

The right working of physiological proc-

[1] Read in the joint meeting of Section K of the American Association, the American Physiological Society and the American Society of Biological Chemists at Cleveland.

[2] See Merz, "A History of European Thought in the Nineteenth Century," Vol. I., p. 129.

esses depends, then, upon accurate adjustment and preservation of physico-chemical conditions within the organism. Such conditions as temperature, molecular concentration and neutrality are now known to be nicely adjusted and maintained; adjusted by processes going on in the body, maintained by exchanges with the environment. This paper is concerned with those physiological processes whereby the normal reaction of the body fluids is permanently preserved.[3]

Throughout the human body, while life exists, there occurs a regular formation of acid substances, excretory products of metabolism. As they form, these various matters, carbonic acid, sulphuric acid and phosphoric acid in the main, immediately combine, but only partially, according to their several avidities, with the basic constituents of protoplasm and blood. In pathological conditions great quantities of acetoacetic acid and β-oxybutyric acid may be produced and claim their share of base. At irregular intervals varying quantities of acids and bases pour in with the food. Thus, through resulting changes in equilibria between bases and acids, normal metabolism steadily operates to lower the unvarying alkaline reaction (almost neutrality[4]) of the body. This tendency to acidity is held sharply in check by special protective mechanisms, acting coordinately, in cooperation and regular succession.

The chemical reactions whereby such material is first neutralized, the chemical substances which aid in neutralization, the shares of more important substances in the process, and their efficiency, the changes in chemical equilibria, including resulting changes in hydrogen and hydroxyl ion concentrations, all, *so far as they concern true solution*, are known with a fair approach to certainty. Principally this work of neutralization is done by salts of phosphoric and carbonic acids, with aid from the amphoteric proteins. In simplified form the process may be represented by the two reactions,

$$M_2HPO_4 + HA = MA + MH_2PO_4;$$

$$MHCO_3 + HA = MA + H_2CO_3,$$

where M stands for any basic radical, A for any acid radical. Other less important simultaneous reactions are of the same type, except perhaps the union of the weak acids with basic proteins like globine, and the union of bases with more acid proteins. Through the remarkable circumstance that phosphates and carbonates possess, among all known chemical substances, the highest power to preserve neutrality in solution,[5] this function is so well performed that the alkaline reaction of the body scarcely varies, even when the load upon the mechanism is heavy.

But, however efficient such an arrangement may be, it is of its very nature only the first stage in the process of the excretion of acid, and wholly dependent upon constant support by the kidney, and of course upon a supply of alkali in the food. Regularly, as they form, the acid bodies must be afforded alkali by blood and protoplasm, for every molecule of carbonic acid about 0.93 molecule of alkali, for every molecule of phosphoric acid 1.89 molecules of alkali, and for every molecule of sulphuric acid 2 molecules of alkali, in accordance with chemical laws and the normal reaction of the body. Clearly, therefore,

[3] See L. J. Henderson, "The Theory of Neutrality Regulation in the Animal Organism," *American Journal of Physiology*, XXI., 427, 1908, and "A Critical Study of the Process of Acid Excretion," *Journal of Biological Chemistry*, IX., 403, 1911.

[4] The terms may be used interchangeably for an alkalinity which is so slight.

[5] L. J. Henderson, *American Journal of Physiology*, XXI., 173, 1908.

this neutralization must rest upon physiological processes which serve to reestablish the original conditions, for if such great amounts of alkali were discharged from the body with the acid excretory substances, the organism would lose its protection and acidity would speedily ensue throughout the system. Thus an imperative necessity arises for the retention of a part of the alkali which serves as a carrier in the process of removing acid from the body. Of course the necessary magnitude of such alkali retention by the kidney varies with the net amount of alkali ingested and with the acid formation of the body.

The conditions in man are closely paralleled by those in other higher animals, and there is reason to believe that constancy of alkalinity is quite the earliest and most universal physico-chemical regulation of active protoplasm. In fact, as the investigations of Palitzsch[6] show, the ocean itself is likewise quite constant in its alkalinity. It is worthy of note that this is due to the simultaneous presence of carbonic acid and bicarbonates in the sea water, a fact which lends support to Macallum's ideas about the derivation of the body fluids. Thus active protoplasm everywhere, as well as that which surrounds it —the environment and the *milieu intérieur* —appear to be and to have been always of stable reaction.

According to the modern theory of solution water itself, like the dissolved electrolytes, is dissociated into ions, though only to a very slight degree. The reaction is expressed thus:

$$H_2O = \overset{+}{H} + O\overline{H}.$$

If the water be pure the concentrations of hydrogen and hydroxyl ions are necessarily equal, for water is electrically neutral. A variety of independent methods of estimation have shown that at 25° this concentration amounts almost precisely to N/10,000,000 in the ordinary units. This corresponds to 0.0000001 gram of ionized hydrogen and 0.0000017 gram of ionized hydroxyl in 1,000 grams of water. Further, the theory of solution explains acidity in water by the occurrence of hydrogen ions, formed from dissolved electrolytes, in excess of hydroxyl ions; and alkalinity by a similar excess of hydroxyl over hydrogen ions. Neutrality is, accordingly, the condition when, as in pure water, the two concentrations are equal. In short, expressing the concentration of ionized hydrogen by $(\overset{+}{H})$ and of ionized hydroxyl by $(O\overline{H})$, if

$$(\overset{+}{H}) = \frac{N}{10,000,000} = (O\overline{H})$$

the solution is neutral. If

$$(\overset{+}{H}) > \frac{N}{10,000,000} > (O\overline{H})$$

the solution is acid. If

$$(\overset{+}{H}) < \frac{N}{10,000,000} < (O\overline{H})$$

the solution is alkaline.

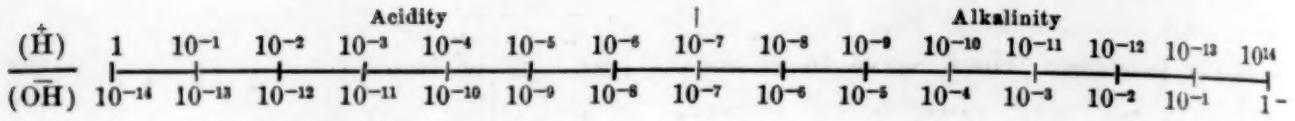
It remains to point out that implicit in these definitions is the well-founded hypothesis that in water the concentrations of hydrogen and hydroxyl ions vary inversely, so that, with constant temperature, under all circumstances their product is constant:

$$(\overset{+}{H}) \times (O\overline{H}) = K.$$

Thus the nature of acidity and alkalinity may readily be represented by a straight line with the neutral point at its center, acidity increasing in one direction, and alkalinity in the other.

Whenever a weak acid is present in aqueous solution in company with such bases as sodium, potassium, calcium, magnesium, etc., which are invariable constitu-

[6] *Comptes-rendus des travaux du Laboratoire de Carlsberg*, X., 85, 1911.



ents of the ocean, blood, protoplasm, etc., *provided the acid be in excess,* it is a simple matter to determine the reaction, which can best be measured by the values of $(\dot{H})$ and $(\bar{O}H)$, following the considerations above.

For this we possess a host of reliable data and a tried and well-seasoned theory —the mass law. Now there is, in connection with the application of the mass law to ionization, a certain characteristic property of an acid, its ionization constant, k, which measures its tendency to dissociate in aqueous solution, thereby to produce hydrogen ions, and hence to increase the intensity of acidity. Strong acids have ionization constants which are of the order of magnitude of 1.0, weak acids of the order of magnitude of 0.0001, the weakest acids, 0.00000001, or less.

TABLE OF IONIZATION CONSTANTS

HCl, HNO_3, etc.	1
H_3PO_4	0.011
H_3AsO_4	0.005
HNO_2	0.0005
H_2CO_3	0.0000003
NaH_2PO_4	0.0000002
H_2S	0.000000091
H_3BO_3	0.0000000007
Na_2HPO_4	0.00000000000036

It has been discovered that in the general case above discussed of weak acid and salt, the concentration of ionized hydrogen is always almost exactly proportional to the ratio of free acid to salt, and is equal, in very close approximation, to the product of this ratio by a number slightly greater than the ionization constant of the acid. That is to say, representing free acid by HA and salt by BA.

$$(\mathrm{H}) = k \times \frac{HA}{BA},$$

whence, if $k = (\dot{H})$

$$\frac{HA}{BA} = 1.$$

From this relationship therefore follows the conclusion, fully established by experiment, that whenever in such a solution the excess of acid, HA, is chemically equivalent to the quantity of salt, BA, the hydrogen ion concentration is almost exactly equal to the ionization constant of the acid, and this is one of the very best methods quickly to detect and characterize an acid. But the ionization constant of carbonic acid (first hydrogen atom) at room temperature is 0.0000003. Hence, in a solution containing exactly equivalent quantities of free carbonic acid, for example, sodium bicarbonate, the hydrogen ion concentration must be approximately 0.0000003 N. Further, since

$$\frac{HA}{BA} = \frac{(\dot{H})}{k},$$

if the amount of acid be ten times the amount of salt

$$\left(\frac{HA}{BA} = 10\right)$$

the hydrogen ion concentration must be about 0.000003 N, and if the reverse be the case

$$\left(\frac{HA}{BA} = \frac{1}{10}\right)$$

the value must be nearly 0.00000003 N.

The range of variation of concentration of hydrogen ions in the usual solutions of the chemical laboratory considerably surpasses the limits of 1.0 N and 0.00000000000001 N. In comparison with such enormous differences those between 0.000003 N and 0.00000003 N are almost negligible (1/100: 1/100,000,000,000,000). Hence ordinarily it is quite accurate enough to speak of any

solution containing both free carbonic acid and a bicarbonate, when the disparity between the concentrations of the two substances is not very great, as of constant reaction. For, obviously, the neutral point, which at a temperature of 25° amounts to a concentration of hydrogen and hydroxyl ions 0.00000001 N, falls well within the narrow range of reaction of such solutions, being characterized by a ratio of carbonic acid to bicarbonate of about 1:3.

Thus carbonic acid, like the almost equally weak acid, phosphoric acid (after its first hydrogen has been neutralized by base), has the remarkable property of preserving a neutral reaction whenever it exists in solution with its salts, provided there be an excess of acid. All acids whose strength is even a little either greater or less than carbonic acid lack the property. There is nothing mysterious about this fact; any other weak acid will hold constant the reaction in its own range of reaction; thus acetic acid in the neighborhood of a hydrogen ion concentration N/100,000, etc.

This characteristic of carbonic acid is of the utmost significance, first by regulating one of the most fundamental of physico-chemical conditions, and secondly, by preserving throughout nature the characteristic chemical inactivity of water, which disappears whenever the reaction becomes either appreciably acid or appreciably alkaline. Almost the only case of important geological action due to acidity or alkalinity of water is the action of fresh water, containing carbonic acid itself, to weather the rocks. This process is however self-limited, for the dissolved material forms bicarbonates, and thus at once provides permanently balanced solutions.[7]

[7] L. J. Henderson, "The Fitness of the Environment," Chapters IV. and V. New York, The Macmillan Company, 1913.

Elsewhere, within and without the organism, carbonic acid is almost always accompanied by bicarbonates, and a close approach to neutrality is the result. In the organism the variation in ratio of phosphates is similar to the case of the carbonates, as may readily be illustrated by experiment. Thus a solution consisting of equal parts of monosodium phosphate and disodium phosphate will be found to give a neutral reaction with both methyl orange and phenol phthalein, and the neutrality, thus indicated, will not be disturbed by the addition of relatively large amounts of either acid or alkali.

We may next consider the equilibrium within the organism, where the concentration of ionized hydrogen can undoubtedly vary between 5 N/100,000,000 and N/10,000,000, but during life probably not much more widely, in the body at large. At body temperature the most probable values of the ionization constants of the acids in question yield the equations:

$$(\dot{H}) = 6.9 \times 10^{-7} \times \frac{H_2CO_3}{NaHCO_3},$$

$$(\dot{H}) = 2.1 \times 10^{-7} \times \frac{NaH_2PO_4}{Na_2HPO_4}.$$

If

$$(\dot{H}) = 0.5 \times 10^{-7}\ N$$

$$\frac{H_2CO_3}{NaHCO_3} = \frac{1}{13.8}, \quad \frac{NaH_2PO_4}{Na_2HPO_4} = \frac{1}{4.2},$$

and if

$$(\dot{H}) = 1.0 \times 10^{-7}\ N$$

$$\frac{H_2CO_3}{NaHCO_3} = \frac{1}{6.9}, \quad \frac{NaH_2PO_4}{Na_2HPO_4} = \frac{1}{2.1}.$$

In short, in order to bring about this seemingly insignificant change in reaction, the relative quantities of acid and base in the body must undergo very great changes; or, otherwise stated, until very large quantitative changes in the amount of acid or base in the body have come about, there can be no appreciable change in the reaction.

In the case of carbonic acid the equilibrium is further complicated by the activity of the lung in excreting the free acid and regulating the concentration of that substance, which is kept nearly constant. Thus, when acid reacts with bicarbonate in the body, it diminishes the latter substance without increasing the amount of the acid. In this manner through the escape of carbonic acid, the efficiency of the equilibrium in the preservation of neutrality is further greatly increased. Thus it is that even in extreme acid intoxication, as for instance diabetic coma, almost the only chemical change that can be detected, as a result of the action of enormous quantities of acid through long periods of time, is a large diminution in the bicarbonates of the blood; in the instances above calculated this would amount to a decrease of about 50 per cent. in the total carbonic acid. Meantime about 20 per cent. of the phosphoric acid of the body will probably be changed from alkaline to acid phosphate, and the proteins will have given up a portion of the alkali with which they are combined.

The recognition of the fact that diminution of bicarbonates is the principal effect of acid intoxication upon the blood, involves important consequences. On the one hand it has become clear that the therapeutic use of sodium bicarbonate is desirable in a large variety of pathological conditions and, on the other hand, it seems to be certain that the evil effects of acidosis largely depend upon interference with the transport of carbonic acid and its excretion from the body. In truth this equilibrium is intimately associated with the respiratory function, and with a great number of other fundamental physiological activities, and with the osmotic pressure of the cell.

Further the profound influence of hydrogen and hydroxyl ions upon many enzymatic processes, and upon colloids in general has been established, and it is gradually becoming clear that all the physico-chemical conditions in protoplasm—alkalinity, osmotic pressure, colloidal swelling, chemical equilibrium, temperature—are interdependent, and that carbonic acid and the acid-base equilibrium are among all these things probably the most important variables.

The reason why it may be asserted that carbonic and phosphoric acids and the proteins are the only important substances which are involved in the physiological regulation of neutrality is that, for the body as a whole, in the narrow range of reaction which can actually occur, these substances can neutralize about 30 liters of 0.1 N acid, and nothing else except other substances of like ionization constants, in equal concentration, even with the advantage of the escape of acid, can do as much.

It can not be too strongly emphasized that this conclusion applies only to the true aqueous solutions of the body. Of the colloidal phase we have no knowledge, but it is evident that they may act as reservoirs of supply and as vehicles of escape.

It is also evident that, if enough acid be produced locally, for instance, lactic acid in the muscle, the protective mechanism may be overthrown, and true acidity result. There is an important connection between this consideration and theories of fatigue and muscular contraction.

But, as for the assertions themselves, they rest upon one of the immutable properties of matter. Phosphoric and carbonic acids in solution everywhere possess this characteristic, independent of the presence of everything else, just as they everywhere possess their characteristic chemical composition.

Thus it is that the regulation of reaction of blood and protoplasm manifests the very highest stability.[8]

In exactly the same way that neutrality is favored by the ionization constant of phosphoric acid, the excretion of acid is facilitated. By variation of the relative amounts of acid and alkaline phosphates the relative amounts of acid and basic constituents of the urine may be varied in the highest degree, accompanied by the very smallest possible variations of hydrogen ion concentration. Thus the presence of phosphoric acid makes of the urine an ideal regulatory apparatus for the preservation of the normal ratio of acid to base in the blood.

Such are the more striking aspects of this subject. Neutrality is quite as definite, quite as fundamental and quite as important a characteristic of the organism as its temperature, or osmotic pressure, or in fact anything else that we know. And it turns out to possess those remarkable characteristics of stability that have been revealed by the researches of Rubner and others in the case of temperature, only in far higher degree.

Within wide limits of amount any acid or base may be poured into the organism, and the reaction will not vary; nor will it vary if such be produced by the organism, and this constancy will protect all enzymatic processes, the function of respiration and the whole distribution of material throughout the body.

Let us return to Cuvier's vortex. Into it let us pour anything, for example hydrochloric acid. No sooner has it entered than it is neutralized, and neutralized it remains until, on leaving the body, it appears as sodium chloride, ammonium chloride and a slightly heightened excess of acid phosphate over alkaline phosphate in the urine.

The urine is variable, the ingesta are variable, even the products of metabolism are variable; but, while life endures, the dynamical equilibrium of hydrogen and hydroxyl ionizations persists.

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[8] For a larger survey of this whole subject two articles in the *Ergebnisse der Physiologie*, VIII., 254, 1909 (the author) and XII., 393, 1912 (Sörensen) may be consulted.

THE PHYSIOLOGICAL SIGNIFICANCE OF SOME SUBSTANCES USED IN THE PRESERVATION OF FOOD[1]

FOOD preservatives are those substances which delay or prevent the decomposition of food as a result of the action of bacteria or other ferment-producing organisms. Other substances, sometimes classed as preservatives, and in the popular mind associated with them, are not so much preservatives as agents for the conservation of some special property of the food in question, as, for example, the use of copper sulphate in the fixation of the color of green vegetables. A large number of bodies may be included under the head of preservatives, but our interest to-day centers in the so-called "artificial" or "chemical" preservatives, because of the question of the permissibility of using them. Some of these bodies have been condemned largely because of their origin, because of their artificial character, which basis of condemnation can not be regarded as sufficient or scientific.

Their merits or faults must be decided on the basis of physiological behavior, essentially, and from this point of view I wish to speak of several substances concerning which the discussions have been

[1] A paper read before the Fifteenth International Congress on Hygiene and Demography, Washington, September 23, 1912.

the most heated. These discussions will be necessarily brief.

SODIUM BENZOATE

On certain phases of the behavior of sodium benzoate there is an abundant literature. Following the pioneer investigations of Meissner and Shepard, and Bunge and Schmiedeberg on the synthesis and estimation of hippuric acid it was recognized that benzoic acid, cinnamic acid, quinic acid and other bodies are normally combined in the animal organism with glycine and excreted as hippuric acid. It was shown, also, that many aromatic fruits and vegetables contain these organic acids which go into the benzoyl combination. Numerous later studies have shown the extent of the glycine, or potential glycine, available in the human body for combination.

With the recognition of this normal character of the hippuric acid synthesis no great objection was raised to the administration of large doses of the benzoate in certain diseases, and going back some thirty years we find a considerable record of clinical experience on the dosage of benzoates in pulmonary tuberculosis, rheumatism and diphtheria. It was shown by many physicians that doses of 5 to 25 grams a day might be given without apparent harm to the patient. This extended experience was sufficient to show that the toxic effect of the benzoate was of a very low order, not much greater possibly than that of sodium chloride.

At the time when sodium benzoate was considered important therapeutically the question of its use as a food preservative had not arisen, and the interest attaching to it then and through the following discussions was in no wise influenced by the present practical question. To what extent may benzoic acid be combined or detoxified in the animal organism? The earlier observers soon recognized that ordinarily and normally it combines with glycine to form hippuric acid, and the question of the available supply of this amino acid was discussed for a long time. In 1898, in experiments on rabbits, Wiener[2] concluded that while large doses of benzoic acid, about 1.7 gram per kilogram of body weight, were usually fatal, smaller amounts and up to the quantity yielding 1 gram of hippuric acid per kilogram of body weight, were combined and detoxified. He believed that the value for the combined benzoic acid, that is, the hippuric acid, was rather constant, the maximum being the 1 gram per kilogram of weight. The usual figures were between 0.7821 and 0.8345 gram per kilogram. From this he concluded that the available supply, or stored-up glycine, must amount to 0.3276 to 0.3496 gram per kilogram of weight. He observed that free benzoic acid appeared in the urine when amounts in excess of the maximum values quoted were ingested.

These observations were made at a time when glycine was looked upon as an important intermediary product of protein metabolism, and before much was known concerning the quantitative relations of the amino acids in the protein molecule. It was later shown that the mean glycine content of the ingested proteins is not far from 4 per cent. of their weight, and that the benzoic acid combined to form hippuric acid may be far greater than the weight corresponding to this glycine content. A stored-up reserve of glycine was for a time assumed to account for the remarkable hippuric acid formation reported by several observers, but this view has been pretty generally abandoned. In this connection the researches of Parker and Lusk,[3]

[2] *Schmied. Arch.*, 40: 313.

[3] *Am. Jour. Phys.*, 3: 472.

Wiechowski,[4] Cohn,[5] Magnus-Levy,[6] Lewinski[7] and others, should be referred to. All of these observers found that in the increased ingestion of large amounts of benzoic acid in animals there was an increased protein metabolism, with increasing amounts of the benzoic acid not combined as hippuric acid. In the Lewinski investigations rather large weights of benzoic acid, as the sodium salt, were given to men. In one case a man of 59 kilograms weight took 12 grams of the acid in 12 hours. All was excreted in combined form and no increase of reducing substances in the urine was noted. This amount of acid is nearly one fifth of a gram per kilogram of body weight, and is relatively less than was ingested in many of the animal experiments. If all combined with glycine it would call for 7.38 grams of the latter, or the glycine existing in about 200 grams of mixed proteins. This amount is probably more than was metabolized in the individual in question.

In another case of Lewinski's a man weighing 67 kilograms took 20 grams of the acid in 12 hours. The urine examination showed the same result as in the other case. Later, the same man took 25 grams of the acid, but it was not all combined, as 1.65 grams were recovered from the urine. When the ingestion was increased to 40 grams still more appeared in the urine uncombined with glycine. In one case on the 40-gram dosage nausea and headache were noted, but these effects seemed less marked with a diet rich in protein. The author concludes that on a high protein diet more benzoic acid may be ingested without ill effects. In one case a man took 50 grams without apparent disturbance, but over 8 grams appeared in the urine uncombined.

All these experiments demonstrate that in man, as well as in animals, ingested benzoic acid may be detoxified in amounts which much more than correspond to the glycine of protein that may be metabolized normally in the same individual, in the same time. The 20 grams of benzoic acid given in one experiment, and which left no free acid in the urine, would correspond to 12.3 grams of glycine.

These papers have been cited because they show the remarkable capacity of the animal organism for the synthesis of hippuric acid and consequent disposition of ingested benzoic acid. It has been shown that the combining power of glycine is not limited to that preformed, or which may be split off in the ordinary metabolism, but that in addition the potential glycine of other amino groups is also available.

It may be urged that this diversion of potential glycine from more complex acids is in itself an abnormal action, and therefore objectionable. This is possibly true, and would have weight, if we were concerned with the question of ingesting daily 5 grams or more of benzoic acid. But the amounts to be practically considered are so far below this that the question of breaking down extra protein does not come to the front at all.

What amounts of benzoic acid are actually in question here? Practically below 500 milligrams daily, if we consider the ordinary solid or semi-solid foods, or below a gram a day, if we consider certain beverages sometimes treated with benzoate. These are probably extreme figures, as for the great majority of food substances benzoate is not used or in any sense required. What then is the physiological behavior of these small amounts of benzoic acid which

[4] *Hofmeister's Beitraege*, 7: 204.
[5] *Jaffe Festschrift*, Braunschweig, 1901.
[6] *Münch. Med. Wochensch.*, 52: 2168; *Biochem. Zeitschr.*, 6: 502 and 523.
[7] *Schmied. Arch.*, 58: 397.

have practical significance? Several lines of enquiry may be followed to find an answer to this question, three of which are comparatively direct: (*a*) the fate in the body; (*b*) the action on digestive ferments; (*c*) the action with reference to general health and metabolism.

(*a*) With reference to the relations under (*a*) we have already sufficient information. Small amounts of benzoic acid are completely united with glycine, and for 500 milligrams 307.5 milligrams of the latter are required, an amount far within the liberation from the ordinary protein metabolism. In the cases of infants or invalids with lower metabolism the possible benzoate ingestion is naturally far below this, and there would doubtless be always, even in such extreme cases, a sufficient glycine content for combination.

With no benzoic acid ingested the larger part of the glycine would probably go to form urea and other products by oxidation. With the benzoic acid we have the synthesis of hippuric acid. Unfortunately, we have no reliable means of comparing the magnitude of or the difficulty in the enzymic work in the two cases. In certain quarters much has been said about the over-burdening of the kidneys with this work of synthesis. As a matter of fact there is no warrant whatever in the assumption that the tax on the organism is any greater in this case than in the other, and those who make the assumption probably overlook the fact that the hippuric-acid synthesis in the human body is normal and constant. Because of a lack of delicacy in the methods employed for the determination of hippuric acid the quantity of this substance excreted daily has usually been greatly underestimated, or neglected entirely.

(*b*) The behavior of benzoic acid toward digestive ferments has been the subject of several investigations. In this direction the action on diastases, pancreatin, pepsin, rennin and the lipases has been studied. A number of such studies have been carried out in my own laboratory, with the general result that while there is naturally an inhibition of digestive activity with certain concentrations of benzoic acid, with those concentrations which have practical importance in the present enquiry the inhibition is very slight or does not appear at all.

In the case of the digestion of starches there is indeed a distinct acceleration in the rate of digestion, as is caused by a number of neutral salts and acids of low concentration. This is true not only of digestions by means of malt infusions, but also in the case of taka-diastase and a number of the pancreatic diastase preparations in general use in this country. Similar results were reported some years ago by Leffmann.[8]

While 0.1 per cent. of sodium benzoate added to egg albumin mixture, such as is used in the official pepsin tests, distinctly retards the rate of digestion, this is not the case with one fifth of this concentration, which is probably above the limit ever found in the stomach after the ingestion of benzoated foods. This relation has been observed in a number of mixtures of fibrin as well as egg albumin, and with a variety of pepsin preparations. Analogous results have been reported by Gerlach in his lengthy study of the benzoate question.[9]

Very weak concentrations of either benzoate or benzoic acid have no influence on the rennin coagulation of milk, but with an increase in the concentration there is a gradual inhibition. Our results in this

[8] *Jour. Frank. Inst.*, 147: 1899, p. 97.
[9] Wiesbaden, 1909.

respect are not essentially different from those of Weitzel.[10] In the clinical feeding of infants sodium benzoate has been frequently added to milk.

According to Amberg and Loevenhart[11] the activity of lipase, as measured by the splitting of ethyl butyrate, is not diminished by the presence of 0.1 per cent. of sodium benzoate. Dakin, working in Herter's laboratory, has made a careful redetermination of many of the digestive constants in presence of benzoate.[12]

(*c*) We now come to the most important part of the subject, the behavior of benzoic acid with reference to general health and metabolism. At the time when this substance was extensively used in medical practise, that is, from 1875 to 1880, it was recognized by some physiologists that large doses were followed by increased elimination of nitrogen, which, it was assumed, must come from the breaking down of body proteins. E. Salkowski, especially, from experiments on dogs,[13] concluded that high doses might occasion a considerable loss in man. But in the dog experiments the ingested benzoate amounted in the mean to about one third of a gram per kilogram of body weight, which proportion if applied to a man of 50 kilograms weight would call for nearly 17 grams of benzoate, or 25 grams for a man of 75 kilograms weight. Somewhat similar observations were made by other physiologists, but on the other hand the reports from clinical practise failed to show any such losses. To follow these discrepant observations farther is not necessary in this place, as the question of the increased nitrogen excretion has been pretty fully handled in the investigations of Magnus-Levy,[14] Ringer, and Epstein and Bookman,[15] and others already referred to.

But these early reports have had one very important effect, which must be recalled here. They left the impression that the ingestion of sodium benzoate is in general followed by increased protein metabolism, tissue metabolism possibly, an undesirable result, and this statement is frequently repeated as applicable to all doses of benzoate. A number of lengthy metabolism experiments have shown that for ordinary ingestions of benzoate this increased protein metabolism does not occur. In the last few years the results of several such investigations have been published. One of these investigations was conducted under the auspices of the Bureau of Chemistry of the United States Department of Agriculture, and from it the conclusion was drawn that small doses of benzoic acid or benzoates exert a harmful action on man, a slight loss in weight being affirmed in some cases. It is not my purpose to criticize this work here beyond saying that the published data do not seem to warrant the conclusions drawn, which opinion is shared in a lengthy review of the work by K. B. Lehmann, recently published.[16]

I wish to speak more particularly of the results of the extended studies carried out by Chittenden, Herter and myself, as members of a commission appointed by the Secretary of Agriculture to investigate the question anew.[17] In Herter's work four men were observed through periods of four months, while in the investigations of Chittenden and myself six men on a definite

[10] *Arbeiten aus dem kais. Gesundheitsamt*, 19: 1902.

[11] *Jour. Biol. Chem.*, 4: 1908.

[12] Herter, *Jour. Am. Med. Assoc.*, 54: 1774.

[13] *Virchow's Archiv*, 78.

[14] *Loc. cit.*

[15] *Jour. Biolog. Chem.*, 10.

[16] *Chemiker Zeitung*, November 28, 1911.

[17] Report No. 88, U. S. Department of Agriculture, 1909.

diet containing sodium benzoate were observed through a period of four months.

These studes covered lengthy observations on the general metabolism of the men, the qualitative changes in the urine, the effects on the blood, effects on the intestinal flora, and daily clinical observations on the weight and general condition of the men. Under the head of metabolism determinations were made of the nitrogen balance and utilization, the distribution of nitrogen, the distribution of sulphur and the utilization of fat. From the data of Chittenden and myself, which were fuller in detail than those of our colleague, certain facts are clearly shown. In Chittenden's series of experiments the doses of benzoate were administered as follows:

	Days	
Fore period	14	no benzoate
Low benzoate period	62	300 mg. daily
After period	10	no benzoate
Medium benzoate period ..	7	600 mg. daily
First high benzoate period .	7	1,000 mg. daily
Second high benzoate period	7	2,000 mg. daily
Third high benzoate period	7	4,000 mg. daily
After period	10	no benzoate
Total	124	71.8 grams

This is an average dosage of 718 milligrams daily, for dosage periods. In my series of experiments the amounts were as follows:

	Days	
Fore period	25	no benzoate
Low benzoate period	60	300 mg. daily
Medium benzoate period ..	14	600 mg. daily
High benzoate period	18	1,000 mg. daily
After period	7	no benzoate
Total	124	44.4 grams

This is equivalent to an average dosage of nearly 483 milligrams daily for the dosage periods. In either case the dosage more than covers the practical consumption and is doubtless better adapted to throw light on the subject than are the excessive doses previously given. Larger ingestions of benzoate are no more suited to prove its practical physiological action than would 150 grams of sodium chloride, kilograms of sugar or half liters of vinegar daily be suitable for these substances. With such large ingestions even the common food substances or condiments might be made to appear highly injurious.

Time will not permit me to go into details with reference to all these experiments. It is sufficient to say that no effects whatever were observed which pointed to a modification of the nitrogen or fat utilization, the nitrogen balance or distribution, the sulphur metabolism, the body weight or the hemoglobin content and red and white counts in the blood. The order of nitrogen distribution remained always the same in the period averages, and it was only when doses of 4 grams of benzoate daily were given that Chittenden noticed a slight, but to be expected, percentage decrease in the urea excretion.

Qualitative Changes in the Urine.—In all of our work frequent examinations were made for the appearance of sugar or other reducing bodies, traces of albumin, casts, aromatic oxyacids, or other things which might indicate a change in the nature of the excreted bodies. There was never any indication of an alteration in this direction. The occasional appearance of a trace of albumin or of a hyaline cast was no more frequent in the dosage periods than in the fore periods, and was without practical significance.

During the progress of the work frequent determinations were made of the so-called normal reduction of the urine of the men working in my laboratory, by means of a delicate ammoniacal copper solution. No definite changes were noted which could be connected in any way with the benzoate. After the conclusion of the 124 days of

regular experimentation two of the men in my group who had followed the regular routine continued for seven days longer, with higher dosage. They began with 5 grams a day and finished with 10 grams, the average being 7.5 grams daily. With this large dosage there was no reduction which could be noticed with Fehling solution, and nothing which was outside the normal limits for the ammoniacal solution, although there appeared to be a slight increase from the former figures. Other changes were absent. A third man who had not been a member of the experimental squad, but who had followed the same diet routine, took doses beginning with 5 grams and ending with 7.5 grams on the seventh day. No abnormal behavior of any description was noted in his excretion or general condition. In this case it could not be urged that the man had become accustomed to large doses through gradually increasing small doses.

Temperature, Pulse, Respiration.—All these factors were systematically noted from day to day for each man. Absolutely no variations from the normal were observed which might in any way be attributed to or connected with the dosage of benzoate.

Conclusions.—From all these observations the conclusion was drawn that in the dosage administered, which is large enough for practical purposes, sodium benzoate exercises no recognizable physiological action on the human organism, beyond the slight increase in hippuric acid excretion, a change which is often exceeded after hearty meals of certain berries and fruits which are frequently consumed in quantity. I have recited the facts in some detail because of the long-continued and persistent attempts to create the impression, especially in this country, that sodium benzoate exerts a toxic action, sufficiently marked to warrant its exclusion from use with foods.

Gerlach's Studies.—Attention must be called here to an elaborate investigation carried out by Dr. Gerlach, of Wiesbaden, on the effects of sodium benzoate as used in the food industries. These experiments were continued through a long period and appear to have been conducted with great care. From the numerous clinical and metabolism observations made Dr. Gerlach draws the conclusion that sodium benzoate causes no changes in the body which may be considered as harmful, or which may be taken as pointing to departure from the normal in any direction.[18]

COPPER SALTS

It has long been a popular notion that copper salts are decidedly toxic and the older medical literature contains many references to poisoning by verdigris and other combinations of copper. Modern study, however, has shown that these assumed effects were greatly exaggerated. The subject has practical interest now because of the custom, which had its origin in France, apparently, of fixing the color of certain green vegetables by cooking them in the canning process in contact with small amounts of copper sulphate, or other copper salt. The effect depends on the formation of a very stable green compound of copper and a derivative of chlorophyll.

The permissibility of the process has been much debated, especially in France, Germany and Belgium. In France the discussion has been a prolonged one and several scientific commissions have taken part in it. Some of the older commissions made reports finding against the use of

[18] Dr. med. V. Gerlach, "Physiologische Wirkungen der Benzoesaeure und des benzoesauren Natron," Wiesbaden, 1909.

copper in this way, but in the more recent studies the results seemed to point to the practical harmlessness of the metal in green peas and beans. In consequence of these French investigations, and later ones in Germany, the use of copper in limited amounts is now tolerated by the food laws of most European countries.

There seems to be no question regarding the physiological action of relatively large amounts of copper salts. They behave as irritant poisons and produce nausea, vomiting, purgation, while the small quantities absorbed exhibit characteristic lesions in the liver, spleen, kidneys and other organs. We are concerned, however, with amounts far below those necessary to cause any such violent symptoms, amounts which could scarcely exceed 15 to 20 milligrams of copper daily in any case, and usually much below this. In the coloring of peas and beans the amount of sulphate used is generally less than 1 gram per kilo, a part only of which becomes fixed in the product, the actual copper content being from 25 to 150 mg. per kilo, ordinarily.

What are the effects of small doses, up to 20 milligrams of copper daily? To answer this question experiments have usually been made with the sulphate or other soluble salt, but it should be recognized that this does not exactly correspond to the practical situation, since in the pea or bean the copper is largely combined as phyllocyanin compound, which in its solubility is very different from the ordinary salts, and is much more stable.

The results of a long series of experiments carried out in my laboratory in the last two years have convinced me that the copper perfectly combined in this chlorophyll derivative is practically without any evident physiological action in amounts up to 12 or 15 milligrams daily, which amounts would be contained in a weight of the vegetable as large as any one could eat with a relish for more than a short period. There appears to be no effect on body weight, nitrogen metabolism, blood factors or qualitative or microscopic blood findings. Nausea is not produced. But the case is somewhat different when we turn to small doses of copper salts given in tea, coffee, milk or beer. Here in time we notice some effect, especially in causing nausea and digestive disturbances, and also in some cases a slight modification of the nitrogen partition and some of the blood factors.

In young vegetables with high chlorophyll content the copper sulphate used in small amount appears to be very perfectly combined. This compound is remarkably stable and resists the action of the digestive ferments to a degree which prevents any great absorption of the copper. In the case of the green pea especially the chlorophyll is largely in the hulls, and these, still green with their copper compound, may pass through the alimentary tract and be found in the feces but little changed. This copper-chlorophyll complex is but slowly broken up by hydrogen sulphide or ammonium sulphide.

In older vegetables, however, where the chlorophyll has become considerably destroyed this copper compound can not be formed to the same extent and the copper added in the canning operation goes into a union with proteins which is easily broken down. In this case the copper acts much as it does in the ordinary inorganic salts. In experiments I have found it possible to add 250 to 300 milligrams of copper per kilo to old green peas, and others have reported still higher additions. Much of this copper may be separated easily by dilute hydrochloric acid.

The fact that the non-ionic copper in the phyllocyanate is practically inert physiologically has been noticed by others. Reference here may be made to the work of Tschirsch,[19] Spiro[20] and Brandl.[21] These writers agree that other compounds of copper have a much more marked effect. From these other combinations, as well as from imperfectly coppered vegetables, the metal may reach the liver and other organs and in time produce a marked effect. In a series of experiments by Chittenden this absorption has been clearly shown. As long as it is not practically possible to limit the use of copper in greening to the youngest vegetables only, and in a specified small amount, it would seem that it might be well to prohibit its use altogether in foods, where, indeed, it serves no useful purpose beyond imparting a bright green color.

SULPHUROUS ACID

Sulphurous acid is used in two essentially different ways in the treatment of food products. First, in the free state or the oxide, and secondly, as a salt, usually sodium sulphite, but sometimes the bisulphite. Some years ago there was for a time a limited application of the true hyposulphite, but this seems to have been abandoned. Sulphurous acid found its first uses in this connection in the protection of must before fermentation, and in the racking off or transfer of wines from one vat to another, or just before bottling. These uses are still in vogue, and other uses have been introduced, especially in the clarification of cane juices before boiling down for sugar, and in the treatment of certain fruits in the sun-drying process. Within comparatively recent times the application of sodium sulphite in some of the minor meat industries and in the canning of certain vegetables was introduced.

It will be seen at a glance that we have here two rather distinct conditions. In the application of the sulphurous acid in the sugar, wine and fruit industries there is finally a pretty complete combination of the product with the sugars to form the aldehyde compounds, from which the sulphite is gradually oxidized. These carbohydrate-containing substances hold also certain organic salts, the acids of which are in part displaced by the sulphurous acid. The protein and fatty substances of meats, however, are in themselves inert toward sodium sulphite, and the latter remains unmodified or combined. The fats, in addition, protect the sulphite from rapid oxidation. Among food chemists there seems to be a practical recognition of this distinction in the active condition of the two classes of sulphured products, and the question of permissibility of use has been advanced generally with reference to the sulphites, rather than as concerns the carbohydrate combinations.

As observed with relatively large ingestions all these products exert, of course, a somewhat toxic action, and the toxicity of the carbohydrate combinations seems to run parallel with their rates of dissociation as aldehyde compounds. For the pure aldehydes the rate is rather rapid in the glucose compound, as the lengthy investigations carried out by Rost and Franz and by Kerp have shown.[22] But in their experiments the rate of dissociation of the glucose aldehyde compound is undoubtedly far greater than would be the case in the commercial combinations of fruits and

[19] "Das Kupfer vom Standpunkte der gerichtlichen Chemie, Toxikologie und Hygiene," Stuttgart, 1893.

[20] *Muench. Med. Wochenschr.*, 56: 1, 1070.

[21] *Arb. aus dem kais. Gesundheitsamt*, 13: 104, 1897.

[22] *Arb. aus dem kais. Gesundheitsamt*, 21: 1904.

syrups, for example, where there is always a great protecting excess of the sugar present. In most of the experiments carried out to test the pharmacological action the dosage of the sulphur compound has been so relatively large as to render difficult a conclusion regarding the behavior of small doses, or those which have practical importance. This is especially true of the experiments of Kionka frequently quoted.[23]

In Lehmann's experiments on dogs and cats, with doses running up to 37.5 and 62 milligrams of sulphurous oxide (150 to 250 milligrams of sulphite) daily, and extending through about 200 days, no definite harmful effects were seen. Lehmann considered these doses relatively large.[24]

I can refer but briefly to the work of two recent French commissions which have studied the behavior of sulphurous acid in wine, with respect to the health of the consumer. As a result of these investigations an official announcement was made about a year ago in France, advancing the allowable content of sulphurous oxide in wine from 350 to 450 milligrams per liter, of which not over 100 milligrams may be in the free state. I have not heard that this tentative standard has been modified.

This whole question is now under review by the commission appointed by the Secretary of Agriculture of this country, but the lengthy investigations undertaken have not yet been brought to a conclusion, and can not, therefore, be discussed here.

JOHN H. LONG

THE THOMAS PENNANT COLLECTION

SINCE the death of Gilbert White's correspondent, Thomas Pennant (1726–1798), the author of "British Zoology," "A Tour in Scotland, Wales and Ireland," and other important works, the collections made by him have remained almost as he left them, at Downing Hall, Holywell, Flintshire. This estate, with the collections, was inherited by a former Countess of Denbigh, and the present owner, the Earl of Denbigh, C.V.O., being about to dispose of it, has presented the whole of the Pennant Collection to the trustees of the British Museum. Accompanying the Collection are several volumes of a manuscript catalogue in which the specimens were, for the most part, entered and numbered. A fairly large proportion of the specimens still bear numbers corresponding with those in the Catalogue, a very fortunate circumstance, since most of the labels that have been preserved had become dissociated from the specimens to which they referred. The Catalogue is accompanied by letters and lists from several of Pennant's distinguished correspondents. Among the 140 birds are the only two known specimens of the extinct British race of capercailzie, as well as the originals of many birds figured in the "British Zoology" (1766). There are also a few mammals, fishes and crustaceans. The recent shells include 16 type-specimens and 70 figured specimens, all described in the "British Zoology." The fossils run to more than 1,000 specimens and include many from foreign localities presented by the Italian naturalist, Allioni, and others. Three of the British Silurian corals were described by Pennant in 1757, and a mammoth tooth from Flintshire was referred to by him in 1771. Of minerals there are about 860 specimens, of which 340 still retain their original labels. Pennant appears to have begun this section of his collection when he visited the Rev. William Borlase, author of "The Natural History of Cornwall," and from him he received specimens from time to time. Other donors were Bishop E. L. Pontoppiden, author of "The Natural History of Norway," and Emannuel Mendes da Costa, author of "The Natural History of Fossils" (1757). Among the Welsh minerals the most important are those from Flintshire which formed the basis for the description of Flintshire minerals published in "The Tour in Wales" (1778). Additions to

[23] *Arch. Hygiene*, 22: 1896.
[24] *Arch. Hygiene*, 66: 303, 1909.

the mineral series were also made by David Pennant, the son of Thomas. Interesting portions of the collection have already been placed on exhibition at the Natural History Museum; but every specimen is to be carefully preserved, and it may be hoped that in course of time the Museum experts will be able to identify yet other specimens of historical importance.

Thomas Pennant was one of the best known naturalists of his day. At an early age he was in correspondence with Linnæus. Buffon, whom he visited in Burgundy, utilized the "History of Quadrupeds." Cuvier, in the "Biographie Universelle," spoke of that work as "encore indispensable," and further accorded high praise to the "Arctic Zoology."

THE POPULATION OF NEW YORK STATE

THE composition and characteristics of the population of New York, as reported at the Thirteenth Decennial Census, are given in an advance bulletin soon to be issued by the Bureau of Census, Department of Commerce and Labor. Of the total population of New York, 3,230,325, or 35.4 per cent., are native whites of native parentage; 3,007,248, or 33 per cent., are native whites of foreign or mixed parentage; 2,729,272, or 29.9 per cent., are foreign-born whites; and 134,191, or 1.5 per cent., are negroes. The corresponding percentages in 1900 were 39.2, 33.2, 26 and 1.4, respectively, the proportion of foreign-born whites having increased during the decade. In 35 of the 61 counties the percentage of foreign-born whites is less than 15; in 18 it is between 15 and 25; in 6 it is between 25 and 35, and in 2, New York and Kings, it is 35 or over. Of the 2,762,522 inhabitants of New York County, 45.4 per cent. are foreign-born whites and only 15.8 per cent. are native whites of native parentage. In 23 counties the percentage of native whites of foreign or mixed parentage exceeds 25, being 42.6 in Queens, 41.5 in Erie, and 40.6 in Kings. Of the urban population, 27.2 per cent. are native whites of native parentage; of the rural, 66.1 per cent. The corresponding proportions for native whites of foreign or mixed parentage are 36.5 and 19.9 per cent. respectively. The percentage of foreign-born whites is 34.5 in the urban population and 12.8 in the rural.

In the total population of the state there are 4,584,597 males and 4,529,017 females, or 101.2 males to 100 females. In 1900 the ratio was 98.9 to 100. Among native whites the ratio is 97.5 to 100, and among foreign-born whites 110.5 to 100.

Of the total native population—that is, population born in the United States—88.7 per cent. were born in New York and 11.3 per cent. outside the state; of the native white population, 10.4 per cent. were born outside the state, and of the native negro, 59 per cent. Persons born outside the state constitute a larger proportion of the native population in urban than in rural communities.

Of the foreign-born white population of New York, persons born in Russia represent 20.5 per cent.; Italy, 17.3; Germany, 16; Ireland, 13.5; Austria, 9; England, 5.4; Canada, 4.5; Hungary, 3.5; Sweden, 2; all other countries, 8.4. Of the total white stock of foreign origin, which includes persons born abroad and also natives having one or both parents born abroad, Germany contributed 21.5 per cent.; Ireland, 19; Russia, 14.8; Italy, 12.9; Austria, 6.7; England, 6; Canada, 4.7; Hungary, 2.5; Scotland, 1.6; Sweden, 1.6 per cent.

Of the total population, 9.9 per cent. are under 5 years of age, 17.4 per cent. from 5 to 14 years, inclusive, 19.5 per cent. from 15 to 24, 32.5 per cent. from 25 to 44, and 20.6 per cent. 45 years of age and over. The foreign-born white population comprises comparatively few children, only 7 per cent. of this class being under 15 years of age, while 73.6 per cent. are 25 years of age and over. Of the native whites of foreign or mixed parentage, 38.3 per cent. are 25 and over, and of the native whites of native parentage, 49 per cent. The urban population shows a larger proportion of persons in the prime of life than the rural and a smaller proportion past middle age. Migration to the city and the influx of foreign immigrants explains this, at least in part. Of the urban population, 33.6 per cent. are from 25 to 44 years of age, inclusive, and

of the rural population, 28.3 per cent., while the percentages 45 years and over are 18.3 and 28.7, respectively. The large number of children in families of foreign origin may account for the fact that the proportion of children under 5 is greater in the urban population than in the rural.

The Census Bureau classifies as illiterate any person 10 years of age or over who is unable to write, regardless of ability to read. There are 406,020 illiterates in the state, representing 5.5 per cent. of the total population 10 years of age and over, the percentage being the same as in 1900. The percentage of illiteracy is 13.7 among foreign-born whites, 5 among negroes, and 0.8 among native whites. For all classes combined, the percentage of illiterates is 5.9 in urban communities and 3.9 in rural, but for each class separately the rural percentage exceeds the urban. For persons from 10 to 20 years of age, inclusive, whose literacy depends largely upon present school facilities and school attendance, the percentage of illiteracy is 2.1.

In the population 15 years of age and over 39.8 per cent. of the males are single and 33.7 per cent. of the females. The percentage married is 55.2 for males and 54.5 for females, and the percentage widowed is 4.4 and 11.3 respectively.

SCIENTIFIC NOTES AND NEWS

The council of the British Association for the Advancement of Science has nominated Sir Oliver Lodge to be president for the Birmingham meeting in place of the late Sir William White.

A portrait of Sir William Turner, K.C.B., principal and vice-chancellor of Edinburgh University and professor of anatomy from 1867 to 1903, has been presented to the university. The portrait is the work of Sir James Guthrie. The ceremony took place in the library of the old university, Mr. Balfour, chancellor of the university, presiding. Sir Robert Finlay, K.C., M.P., made the presentation and Mr. Balfour accepted the portrait on behalf of the university.

Dr. E. W. Hilgard, emeritus professor of agriculture at the University of California, is recovering from severe injuries received a few weeks ago, when a flight of steps which he was ascending gave way, throwing him to the floor. The broken bones are uniting and it is hoped that he will soon be able to resume his writing, which was interrupted by the accident.

At the ceremonies connected with the opening of the Phipps Psychiatric Clinic of the Johns Hopkins University Hospital, beginning on April 16, addresses will be given by Sir William Osler and Professor William McDougall, of Oxford; Frederick W. Mott, F.R.S., of London; Professor Heilbronner, of Utrecht; Professor Bleuler, of Zurich, and Professor Orovino Rossi, of Italy.

On the nomination of the council of the University of Paris, M. Jean Perrin, professor of physical chemistry in the University of Paris, has been appointed visiting French professor at Columbia University for 1913–14.

Sir Cecil H. Smith, director of the Victoria and Albert Museum, and Dr. E. H. Starling, F.R.S., professor of physiology in the University of London, have been elected members of the Athenæum Club, London, under the rule which empowers the annual election of three persons "of distinguished eminence in science, literature, the arts, or for public service."

At the dinner of the Chicago Medical Society on February 26 Dr. Abraham Jacobi, New York City, and Dr. Edward Martin, Philadelphia, were the guests of honor.

A reception was given by the Manhattan Medical Society on February 28 to Dr. Jacques Loeb, of the Rockefeller Institute, at which he spoke on "Some Recent Experiments in Artificial Parthenogenesis."

Mr. John J. Schoonhoven, president of the department of zoology of the Brooklyn Institute, has been made a fellow of the institute.

The Rev. A. H. Cooke, known for his work on molluscs, has succeeded Mr. R. Bullen Newton as president of the Malacological Society of London.

MR. FRANK ARMITAGE POTTS, M.A., fellow of Trinity Hall, Cambridge, has been elected to the Balfour studentship.

MR. T. LL. HUMBERSTONE, B.Sc., has been appointed to the Mitchell studentship of the University of London. The studentship, which is of the value of £100, is for the study of some definite feature of business or industrial organization at home or abroad. Mr. Humberstone proposes to investigate the scheme of industrial fellowship in the Universities of Pittsburgh and Kansas under which research work in applied science is promoted with funds provided by, and to some extent under the supervision of, industrial and commercial organizations.

PROFESSOR WILLIAM MCPHERSON, dean of the graduate school and professor of chemistry at the Ohio State University, has been granted leave of absence for the second semester of the current year. He sailed on March 1 for Germany, where he will spend the next six months in research work in chemistry.

MR. LUTHER E. WIDEN, of the University of Iowa, will accompany Mr. Villjalmar Stefansson on his expedition and will make psychological measurements on the Esquimaux.

PREPARATIONS are being made for the despatch of an official French expedition to Franz Josef Land under M. Jules de Payer, son of the Austrian Captain de Payer, who commanded the Austrian expedition that discovered Franz Josef Land in 1873.

MR. ANDERS K. ANGSTRÖM, son of the distinguished Swedish physicist, and now a student at Cornell University, will have charge of a scientific expedition to Mt. Whitney to continue work on the radiation of the sun under the Smithsonian Institution. Mr. Angström was assistant to Dr. C. G. Abbot, director of the Smithsonian Astrophysical Observatory, in his work in Algeria last summer.

PROFESSOR FRANK SMITH, of the zoological department of the University of Illinois, has been requested by the authorities of the United States National Museum at Washington to take charge of its collection of annelid worms belonging to the group of Oligochæta. Professor Smith and his assistants are now at work on the anatomical study and classification of the first installment of material, which includes not only North American forms, but also part of the collection made a few years ago by the Roosevelt expedition to East Africa. The remainder of the material in the possession of the national museum will be sent to Urbana as it is needed.

DR. FELIX KRUEGER, professor of philosophy at the University of Halle and Kaiser Wilhelm professor at Columbia University, lectured on psychological subjects last week at the University of Wisconsin and the University of Illinois.

PROFESSOR W. M. DAVIS, during his recent trip to the middle west, lectured at Oberlin College and the University of Chicago on "Dana's Confirmation of Darwin's Theory of Coral Reefs," and before the Sigma Xi Society of Northwestern University on "Human Response to Geographical Environment"; he also spoke at the Francis W. Parker School, Chicago, on "The Highlands of the Rocky Mountains in Colorado."

THE winter course in highway engineering (February 24 to March 8), given this year for the first time at the Ohio State University, has proved to be popular with the engineers of Ohio who are engaged in highway construction. Contractors, inspectors and county commissioners to the number of sixty enrolled for the course. The Ohio Good Roads Federation cooperated with the university in meeting the expense. The lectures covered many phases of highway construction, maintenance and materials. Among the special lectures were Professor A. H. Blanchard, of Columbia University; A. N. Johnson, state highway engineer of Illinois, and J. J. Voshell, U. S. highway engineer, Washington, D. C.

THE fifth annual meeting of the Illinois Water Supply Association was held at the University of Illinois on March 11 and 12. Members of the association are interested in obtaining and conserving an abundant supply of pure water in the state of Illinois. Special

exhibits are to be placed in the hydraulic and the state water survey laboratories. Among the speakers announced were: Dr. E. O. Jordan, professor of bacteriology, University of Chicago; Dr. W. L. Lewis, professor of chemistry, Northwestern University; Dr. S. A. Forbes, professor of entomology, University of Illinois, and others from these universities, and water supply experts from Chicago, London, England, Charleston, S. C., Cincinnati, Ohio, Washington, D. C., and many other large cities.

Dr. E. C. Jeffrey, professor of plant morphology at Harvard University, lectured at the University of Illinois last week on the formation of coal.

Dr. Albert Ernest Jenks, professor of anthropology, University of Minnesota, delivered five illustrated lectures on the "Philippine Peoples," in New York City, for the Board of Education during the recent intersemester recess.

On the evening of March 6, Professor A. W. Goodspeed, of the University of Pennsylvania, lectured before the Franklin Institute on "The Relation of Electricity to Matter."

Professor George Grant MacCurdy, of Yale University, lectured before the Science Club of Amherst and the Massachusetts Agricultural College on the evening of March 3, the lecture being based on his past summer's work in the European prehistoric field.

On February 28, Dr. L. R. Ingersoll, of the physics department of the University of Wisconsin, gave an address on the "Kerr Effect" before the physics colloquium at the University of Illinois.

Dr. John Shaw Billings, director of the New York Public Library since 1896, previously professor of hygiene at the University of Pennsylvania, surgeon and lieutenant colonel in the army, died on March 10, aged seventy-three years.

Oscar Dana Allen, professor of metallurgy and analytical chemistry at Yale University from 1871 to 1887, died on March 5 at his home at Ashford, Wash. He had written on the flora of Mount Tacoma.

Professor Oscar Oldberg, dean emeritus of the Northwestern University School of Pharmacy, for thirty years a member of the committee of revision of the United States Pharmacopœia, died in Pasadena, Cal., on February 27.

Dr. Arnold Heller, professor of pathological anatomy at Kiel, has died at the age of seventy-three years.

The Pagel collection of books on the history of medicine, being the library of the late Professor Julius Pagel, has been given to the medical department of Washington University through the generosity of a friend of the institution. The library contains about 2,500 titles.

A meeting of the committee appointed to make arrangements for the meeting of the British Association in Birmingham in September was held on March 10, Alderman W. H. Bowater presiding. The Finance Subcommittee reported that promises amounting to £5,493 by 642 local people had been received in answer to the circular sent out to 3,000 persons in January. Sir Oliver Lodge mentioned that the local fund would pay the greater part of the expenses of the meeting, and that the membership subscriptions and general receipts for admission would go into the general funds of the British Association for the assistance of scientific research. Professor Gamble, on behalf of the Halls Committee, said it had been arranged to have the president's address and the evening meeting at Central Hall, while the offices, reception rooms and refreshment rooms would be at the Town Hall and Mason College.

On the occasion of the seventeenth International Congress at London next August, three prizes will be awarded: The Prize of Moscow, commemorating the twelfth congress, of the value of 5,000 francs, will be awarded for work in medicine and hygiene or for eminent services rendered to suffering humanity; the Prize of the thirteenth Congress of Paris, having a value of 4,000 francs, will be bestowed for original work during the past ten years bearing upon medicine, surgery, obstetrics or the biological sciences in their

application to medical science; and the Prize of Hungary, instituted to commemorate the sixteenth Congress of 3,000 crowns, will be given for a notable piece of work in medical science which has appeared in the interval since the last congress. Nominations of candidates for these prizes are invited before June 1, 1913, and should be sent, together with examples of the work on which the candidacy is based, to the Bureau de la Commission permanente des Congres internationaux de medicine, Hugo de Grootstraat 10, The Hague.

THE Southern Society for Philosophy and Psychology will hold its eighth annual meeting at the Johns Hopkins University, Baltimore, on April 8 and 9.

THE annual meeting of the American Breeders' Association was held at Columbia, South Carolina, in affiliation with the National Corn Exposition, January 24–27, 1913. As usual in recent meetings of this association, the work of the eugenics section was especially prominent. Dr. Charles B. Davenport's evening lecture to the citizens of Columbia on eugenics and the colored race was received with interest. He gave a general view of the difficulties brought about by the blending of the unit characters of two races so radically different. A feature of the work of the plant section was a visit to the state experiment station booths at the National Corn Exposition, which is really a national farm crops exposition. A plant-breeding expert in each of nearly a dozen states received the association at his booth and with samples at hand told of one or more varieties of corn, wheat, sugar cane, or other crop which had been materially improved by the state experiment station and had come into wide commercial use in the state. In each case the method of breeding used in producing the new variety, the percentage of increase it produced over the varieties it is displacing and the acreage covered throughout the state were given. For example, a variety of sugar cane in Louisiana was said to now occupy half the sugar cane area of that state with a yield of canes ten per cent. above the yields of varieties it displaced and with a percentage of sugar in these canes ten per cent. above the old averages. Nearly similar increases were shown in varieties of wheat in Minnesota and Washington, varieties of corn in Indiana, Illinois and other states and varieties of cotton in South Carolina and other southern states.

UNIVERSITY AND EDUCATIONAL NEWS

BY the death in Wallingford, Conn., of Joseph Lyman, Yale University will receive $650,000. He held the life use of that sum which was willed to the college by his brother, Samuel Lyman, who died in 1910.

BOTH houses of the legislature of the state of Washington recently adopted the biennial budget submitted by the joint appropriations committees. The University of Washington will receive $1,004,701. The matter of the replacement of the temporary university buildings by adequate modern structures has been submitted to the legislature separately.

THE recently adjourned legislature of West Virginia gave larger appropriations to the state university than in any previous year. Among others was a special appropriation for the medical work to make it possible to follow out the plans outlined by the committee from the Association of American Medical Colleges.

THE Indiana legislature has made an appropriation of $65,000 for the medical school and hospital of the Indiana University School of Medicine for the first year, and an annual appropriation of $75,000 thereafter.

FUNDS have been provided at Columbia University to build a laboratory for the study of cancer under the George Crocker research fund. This fund amounts to over one and one half million dollars, and it was provided that the income should be used solely for research work. The laboratory, which will be 100 by 40 feet and three stories high, will be on the block east of Amsterdam Avenue on 116th St.

THE clinical and laboratory building of the Stanford University Medical Department in San Francisco has recently been remodeled at an expense of about $40,000. This large building was formerly used by Cooper Medical Col-

lege and had in it, besides the Lane Hall, a number of amphitheaters and lecture rooms, and the Lane Medical Library. With the removal of the Lane Medical Library to its new building across the street and with the shifting of laboratories and the rearrangement of the space formerly occupied by Lane Hall, considerable additional space has been gained for the outpatient clinics and laboratories. The lower floor of the building is devoted entirely to the surgical outpatient clinic, the surgical specialties and the history room and drugstore, the second floor to the medical outpatient clinic and the clinics of pediatrics, neurology and dermatology. The three upper floors are devoted to the pathological museum and the laboratories of experimental medicine, pathology, pharmacology and experimental surgery. Reading rooms have been provided for the students in close connection with the clinical laboratory. This laboratory and the outpatient department are separated by only a short corridor from the clinical wards of Lane Hospital so that both in- and outpatient material is equally available for purposes of teaching. The front part of Lane Hall has been converted into a modern amphitheater suitable for demonstrations. About 12,000 patients were received by the outpatient department during the past year with a total number of visits of over 60,000.

A BILL to establish a college of medicine and dentistry at the Ohio State University is now before the state legislature and has passed the senate. If it becomes a law, the Starling Ohio Medical College of Columbus will be transferred to the state and become the basis of the new college.

CAPTAIN C. E. MARSH, U. S. N., has made public the details of the plan for giving a number of college undergraduates an opportunity to take a summer cruise on some of the navy vessels and thus to familiarize themselves with life on board ship and fit themselves to become members of a sort of naval reserve. The college students will be assigned in squads of 20 to each ship, and as far as possible men from the same college will be kept together.

THE Prussian minister of education has announced that fees at Prussian universities for foreign students will be doubled. Russian students will hereafter be required to be graduates of gymnasia. There has been agitation in Germany recently in regard to foreign students, the University of Munich having limited the number to three per cent. There are at present 5,196 foreigners studying at the German universities, of whom 338 are Americans.

THE 126th anniversary of the granting of the first charter by the legislature of Pennsylvania was celebrated by the University of Pittsburgh on Friday, February 28, 1913. The addresses were given by Provost E. F. Smith, University of Pennsylvania, President E. E. Sparks, State College, and President W. H. Crawford, Allegheny College. The honorary degree of doctor of science was conferred upon John Price Jackson, dean of the School of Engineering, State College.

DEAN F. F. WESBROOK, of the medical school of the University of Minnesota, has resigned to accept the presidency of the University of British Columbia. Dr. Wesbrook, who is a Canadian, has been largely responsible for the development of the medical school of the University of Minnesota and its recent reorganization.

PROFESSOR FREDERICK H. SYKES, director of the School of Practical Arts in Teachers College, has resigned in order to accept the presidency of the new Connecticut College for Women at New London.

DR. FREDERICK E. BOLTON has been elected dean of the new college of education at the University of Washington. Professor Bolton was called to the University of Washington last year from the University of Iowa, where he was director of the school of education.

THE fact that Professor E. B. Greene resigned his position as dean of the College of Literature and Arts of the University of Illinois when he took leave of absence last year, has been made public. The reason Professor Greene gives for resigning is that he did not desire the administrative work in connection with the office. At the time of the resigna-

tion, Dr. Arthur Hill Daniels, professor of philosophy, was appointed acting dean. Dean Daniels' appointment is to remain effective until something definite shall be done in regard to the proposed combination of the College of Literature and Arts, and the College of Science.

MR. C. SHEARER, M.A., Clare College, Cambridge, has been appointed university lecturer in zoology.

DR. CONSTANTIN CARATHÉODORY, of the Technical Institute at Breslau, has been appointed professor of mathematics at Göttingen as successor to Professor Felix Klein.

DISCUSSION AND CORRESPONDENCE

RELATIVITY IN ELECTROMAGNETIC INDUCTION

IN SCIENCE of January 17, 1913, S. J. Barnett adduces a certain experiment as constituting an *experimentum crucis* showing that complete relativity does not exist in electromagnetic induction. The experiment is certainly an interesting one, but on closer examination does not seem to be so definitely in contradiction to the principle of relativity as may appear at first sight.

For discussion let us consider the following simple form of experiment which illustrates the same principles. Take a cylindrical magnet magnetized longitudinally and symmetrically about its axis, and mount it in the axis of a somewhat larger cylindrical metal tube, with air or other dielectric between insulating one from the other, and forming a cylindrical condenser. Connect the two by a metal brush or cross-connection reaching radially across from the tube to the middle of the magnet. Now if the whole system considered as rigidly connected is spun around its axis of figure there will of course be induction and a difference of potential established between the magnet and the outer tube, and if the brush connection be broken while the system is in rotation, on bringing the whole to rest the condenser, consisting of tube and magnet, will be found charged.

So also when the tube alone is rotated while the magnet is kept at rest, a difference of potential is established, provided the metal connecting brush rotates with the tube. Or if the magnet is rotated and the tube kept at rest experiment shows the inductive effect to be the same if only the cross-connection rotates with it. And finally if both magnet and tube are kept at rest while the cross-connection alone is rotated about the axis of the system the observed effect is the same.

On the other hand, no inductive action is observed when tube or magnet or both together are rotated so long as the connecting brush is at rest.

The motion of the cross-connection is thus the determining factor, but relative to *what?* Must not any effect *that we can observe* be due to motion *relative to the apparatus and connections by which the inductive action is tested.*

Of course the induction may be conceived as due to motion relative to coordinates fixed in the ether or in space, and the effect would then depend on the direction of the axis of the magnet relative to the earth's axis, and the rotational velocity of the earth, and on its translational velocity in space. But even in that case the inductive action which also takes place on the system by which the effect is tested, in consequence of its motion in space, may be expected to be such that no inductive action could be *observed* except in case of such relative motion as is specified above.

For so long as the cross-connection and the testing apparatus by which the effect is to be observed are at rest relative to each other no change in the magnetic flux through the circuit will be produced by any rotation of the whole system about the axis of the magnet.

It appears therefore that if the testing apparatus rotates about the axis of the magnetic field at the same rate as the cross-connection between magnet and tube, no charge will be found, while if it rotates with an equal angular velocity in the opposite direction the charge found will be twice as great as if it were at rest.

If these statements are in accordance with the experimental facts, as I believe them to be, then such an experiment can afford no infor-

mation touching the motion of the ether in the field around a rotating magnet.

Arthur L. Kimball

Amherst College,
January 20, 1913

SCIENTIFIC METHOD

To the Editor of Science: Permit me to protest vigorously against the exceedingly narrow conception of scientific method implied in Professor MacDougall's discussion of "neo-vitalism" in your issue of January 17. I am not a defender of neo-vitalism, and have no interest in the controversy between the neo-vitalists and their opponents; but I am interested in keeping the scientific method broad enough to apply to all phases of human experience. It is surely to be deplored that in this age, just when science is expanding to include all human life within its scope, a few scientific men should persist in interpreting scientific method in such a way as to limit its application to purely physical phenomena. If it is true that "natural science rests finally upon the assumption of mechanism [*i. e.*, rigid determination of all processes through the operation of mechanical causes] and excludes all other conceptions," then there can be no scientific treatment of religion, morality or any other phase of the mental and social life of man. Upon this assumption there can only be physical and biological sciences, and we must give up the hope of having mental and social sciences; for the impossibility of demonstrating mechanical causation in the mental and social realms is acknowledged by all careful thinkers and investigators.

Furthermore, the necessity of science assuming the universality of, and the rigid determination by, mechanical causation, is not evident, unless science wishes to transform itself into a system of monistic philosophy. Rather the pragmatic development of science would permit the assumption of one principle of explanation in one realm of phenomena where it works, and of another in another realm, where that works; for science is "a prolongation of common sense." Thus in the physical sciences no other principle than the mechanistic one is invoked, because mechanical cause and effect will work as a principle of explanation. But in a science like economics, for example, there is little use made of mechanical cause and effect as a principle of explanation because it will *not* work. All modern economics, as is well known, is built upon the conception of "value." Now, is economics a science, or not a science? To me the attempt to explain economic phenomena through mechanics is as absurd as the attempt to explain biologic phenomena through "entelechy." In either case it is the attempt to explain the known through the less known. The case is exactly similar with all the other social sciences. It may be replied that economics and the other social sciences are "sciences," but not "natural sciences." This reply, however, does not meet the issue, because no one can separate the natural sciences from other positive sciences unless the word "natural" be defined to mean the physical.

I am uncertain as to the purpose of Dr. MacDougall's argument, as to whether he wishes to limit greatly the scope of science (as do some philosophers), or to carry through the mechanistic conception as a universal principle of explanation (as do some scientists). In either case the argument practically denies the possibility of positive sciences of our mental and social life. To many people this is, of course, a welcome conclusion. But the whole development of modern science is against this conclusion. The extension of scientific methods to the mental and social realms of phenomena in the nineteenth century, without any use of mechanistic assumptions, was accompanied by as substantial triumphs in those realms as science has had anywhere. Is it not time to acknowledge this? It will not do to say that the assumption in all cases where science has made substantial advances in explaining mental and social phenomena has been that of mechanism; on the contrary, the mechanistic assumption, when brought in at all, has been brought in as a metaphysical "guess" which really explained

nothing. The use of such an assumption in most cases in the social sciences has usually turned out to be an attempt to explain the known in terms of the less known.

In conclusion, it seems to me that science *as science* may well beware of accepting as yet any universal principle of explanation. It can not accept such until it is demonstrated. The method of science is not, as some philosophers have proclaimed, to build itself up upon some universal assumption. Rather its methods are the pragmatic ones of observation, comparison, testing by experience and measurement. So far as science approaches exactness it is built up by the method of measurement; and many other things than mechanical cause and effect can be measured. It is decidedly premature as yet to say that science will approve any universal principle or method of explanation; and it is decidedly regrettable that any one who works in any of the sciences should, by a narrow definition of scientific method, rule out of the category of scientific works James's "Principles of Psychology" and the whole list of important contributions in the mental and social sciences not based upon the mechanistic assumption.

CHARLES A. ELLWOOD
UNIVERSITY OF MISSOURI,
January 20, 1913

"MORE LITTLE BEASTS"

TO THE EDITOR OF SCIENCE: Under the title of "More Little Beasts of Field and Wood," Mr. William Everett Cram, of Hampton Falls, New Hampshire, has given an account of various animals met by him in his walks through the woods, written in a pleasant fashion suggestive of Thoreau, though without Thoreau's touch of moral epigrams.

It is illustrated by a number of fairly correct wood-cuts.

A novel suggestion, at first sight not at all convincing, is this, that the group of hares and rabbits is not an off-shoot from the rodents, but from the family of cats, a rabbit in the long past being a cat, adapted perforce to a vegetable diet. A good many parallelisms between the cats and the rabbits are suggested, among others that cat flesh is sometimes substituted for that of rabbits in the inns of Europe.

DAVID STARR JORDAN

SCIENTIFIC BOOKS

The Horse and its Relatives. By R. LYDEKKER, F.R.S. New York and London, The Macmillan Company. Pp. vi + 286; Pls. XXIV., and 11 text figs. 1912. Price $2.60 net.

This extremely interesting volume is a companion to that on the ox and its kindred by the same author, and summarizes most admirably our knowledge of the members of the equine race, both living and extinct. In the opening chapter the place of the horse in nature is discussed, together with that of its few surviving relatives. The eight or nine species of horses, five of rhinoceroses and five or six of tapirs contrast strikingly with the great number of artiodactyles still living. The perissodactyles are therefore looked upon as a waning race, but the cause of their diminution in numbers is not yet determined.

In discussing the structure of the horse, especial emphasis is placed upon the high degree of specialization of feet and teeth. In the foot the variable degree of reduction of the splint bones is of interest, the great shire horse of England retaining the entire shaft together with remnants of the first and second phalanges of the lateral toes, all firmly welded together, while the Argentine horses show the greatest diminution of these bones. The longheadedness so characteristic of all horse-like forms is a very ancient character and gives space before the eyes for the development of the wonderful dental battery. The pit-like depression in front of the orbit sometimes seen in modern horses is supposed to have lodged a scent gland, of recognition value, similar to that of the deer. The leg callosities known as "chestnuts" are also decadent skin glands. The long columnar teeth with their complex infolding of enamel are admirably adapted to the harsh siliceous grasses which constitute the principal article of diet. They are much more perfect than in the cud-chewing ruminants, in which the food

is subjected to a second chewing at the creatures' leisure, after having been softened in the stomach. In the horse the mastication must be hurriedly and efficiently done once for all.

The coloration of living horses gives rise to the belief that the Arab stock has been derived from a dappled bay, while in the domestic horses of western Europe, probably sprung from a different ancestral species, the primitive hue is dun, the color of withered grass. The tendency toward either melanism (black), erythrism (redness) or albinism (white) gives rise to the various color modifications. Striping is characteristic of all African wild horses, while those of Asia are more uniform.

The occasional presence of rudimentary paired horn-like processes upon the frontal bone, while never showing a corneous covering, is of interest. They are not vestigial, as no equine ancestors show them, and while Lydekker does not suggest it, may they not be indications of approaching racial old age?

Cope's idea that the horse tribe had two independent centers of development from animals of more primitive type, one in the old world and a second in North America, is rejected for that of Matthew, who assumes that "since the horses are represented by a double evolutionary series, one in Europe, a closer one in North America, their center of dispersal lay far enough north to spread into Europe on one hand, North America on the other, but that the latter was nearer or more accessible; *i. e.*, their center of dispersal was northeastern Asia or Alaska."

The wild tarpan or Przevalski's horse, still living on the steppes of Tartary and Mongolia, is the only true horse other than the domestic breeds which has survived. Historical evidences for wild horses in Europe may refer to feral animals, the ancestors of which had escaped from bondage. Prehistoric records, on the other hand, such as the drawings on the walls of caves, show the existence of a small, big-headed horse strongly suggestive of the tarpan. This is the so-called steppe type of Ewart. Two others are also represented by bones and teeth in the Pleistocene of England and the continent, one the plateau type of Ewart, a fine-headed, slender-limbed pony, also depicted in paleolithic art; and the forest type, a long, low horse with short, thick cannon bones and broad hoofs. All three of these are probably races of the modern *Equus caballus* and not separate species.

The author next discusses the domestic horses of the British Isles and some foreign breeds, and their probable origin, including the American feral horses. The latter are derived from those introduced by the Spanish conquerors and are of Barb stock.

Among other living equines the Kiang and Onager group come nearest the true horses. They are Asiatic in distribution, while the asses are apparently from the north of Africa. "It has been stated that 'the ass, and with it its name, accompanied the progress of the culture of the vine and olive to the north, not crossing the limits of that culture. In proportion as the ure-ox, the bison, and the elk died out, the long-eared foreign beast became domesticated in Gaul, receiving various names, and living in the customs, jokes, proverbs, and fables of the people. Germany, however, proved too cold for the animal.'" Asses have become feral in South America. Nearly related to the ass is the true zebra of southern and southwestern Africa, which, together with the now extinct quagga and the bontequagga or Burchell's zebra constitutes the distinctively striped horses of the Ethiopian realm. The curious association of zebras, gnus and perhaps a troop of ostriches to fill up the company, is mentioned, the ostriches apprehending danger through the sense of sight, the others through that of smell. The coloring of zebras, the protective value of which has been so vigorously denied by Colonel Roosevelt, is summarized by the statement that "whatever may be the real truth with regard to some of the disputed points, it is certain that when a zebra enters covert, it becomes, owing to its coloring, indistinguishable."

The final chapter summarizes our knowledge of the extinct forerunners of the horse, the records of which have been so well preserved.

Through each of the five stages—Pleistocene, Pliocene, Miocene, Oligocene and Eocene—of the uppermost eras of geological history we can trace a more or less complete gradation from the horses of the present day to primitive, many-toed animals, scarcely larger than foxes, and presenting few of the features which render the horse and its relatives such a remarkable group. Some idea of the immense lapse of time which has taken place during the slow evolution of the Eocene *Hyracotherium* into the modern *Equus* has been thus expressed by Professor H. F. Osborn, whom Lydekker quotes:

> The Rocky Mountains, it is true, began their elevation during the close of the Age of Reptiles; they had only attained a height of four or five thousand feet when the Age of Mammals commenced; they continued to rise during the entire period. But consider the map of Europe and Asia at the beginning of Eocene time and realize that the great mountain systems of the Pyrenees, the Alps, and the Himalayas were still unborn, level surfaces in fact, partly washed by the sea. . . . The birth of the Pyrenees was at the beginning of the Oligocene. At this time Switzerland was still a comparatively level plain, and not until the close of the Oligocene did the mighty system of the Swiss Alps begin to rise. Central Asia was even yet a plain and upland, and only during the Miocene did the Himalayas, the noblest existing mountain chain, begin to rise to their present fellowship with the sky. In North America, again, since the close of the Eocene the region of the present Grand Cañon of the Colorado has been elevated 11,000 feet and the river has carved its mighty cañon through the rock to its present maximum depth of 6,500 feet.
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> Those who have been impressed with a sense of the antiquity of these wonders of the world, and will imagine the vast changes in the history of continental geography and continental life which were involved, will be ready to concede that the Age of Mammals alone represents an almost inconceivable period of time.

RICHARD SWANN LULL
YALE UNIVERSITY

Electricity and Magnetism for Advanced Students. By SYDNEY G. STARLING. Longmans, Green & Co. 1912. 583 pages, with 452 figures.

This book is the outcome of a number of years' experience in teaching the subject to senior students in an English municipal technical school, and it is a good book. To quote from the preface, it aims "to give such students an adequate knowledge of the present state of the subject, with due reference to the historical sequence of its development, and to the effect of modern research upon it." Its seventeen chapters are devoted to magnetism, terrestrial magnetism, the electric current (2), electrostatics (2), electrolysis, thermoelectricity, electromagnetics, magnetic properties of materials, varying currents, alternating currents, units, electromagnetic radiation, conduction in gases, radioactivity, and electrons. Instruments and methods of measurement receive a great deal of consideration. Each chapter is provided with a number of examples, mostly taken from London B.Sc. and B. of E. papers.

The book follows for the most part conventional lines. Its descriptive matter is clear and full and usually correct. Its mathematical demonstrations are ordinarily sufficiently direct and simple, though it seems to the reviewer that some of them might have been dispensed with and that others, *e. g.*, those pertaining to the Wheatstone and Thomson bridges, would profit by simplification. The calculus is freely used throughout.

As to matters of fact the book is fairly up to date. In many cases, however, important recent contributions receive no mention—such as the use of the methods of electromagnetic induction in terrestrial magnetism, the precise work of Rosa and Dorsey on the ratio of the unit charges, and the brilliant work of Langevin, Weiss and others in the domain of magnetism.

In matters pertaining to fundamental theory the treatment is not always logical and free from looseness. Thus the definitions of electromotive force and potential difference are unsatisfactory; resistivity is defined without reference to the direction of the streamlines; the curl of a vector is defined as its line integral around a closed path; and Gauss's theorem, demonstrated for a homogeneous field only, is assumed without comment to

hold for all fields—an error common to nearly all books on this subject. And many other errors have been noted, most of them pertaining to the theory of instruments.

As in many other books, great use is made of the magnetic shell. In the reviewer's opinion magnets of all types, real or fictitious, but especially the magnetic shell, should be completely abolished from the fundamental parts of electrical theory—as indeed they have already been abolished by some writers. The reviewer must protest also against the author's use of the word *field,* which properly denotes a *region,* to designate field *strength* or field *intensity;* and the use of the word *force* in place of the word *stress* when two forces—both action and reaction—are contemplated. These usages are all too common, and the book under review is no more guilty than many others.

In spite of such defects as have been mentioned it may be stated again that this is a good book. And it should be useful to many students.

S. J. Barnett
The Ohio State University

The Science of Human Behavior: Biological and Psychological Foundations. By Maurice Parmelee, Ph.D. New York, The Macmillan Company. 1913. Pp. xviii + 443. $2.00 net.

It is the subtitle rather than the main title that indicates the scope of this work, which might perhaps have been better named prolegomena to a science of human behavior. No attempt is made to gather together the rather extensive studies of human behavior already produced by experimental psychology, and indeed the existence of this work is not even recognized, nor are its methods set forth. The author's view is that human behavior must be approached from the biological and physiological side. "Psychical and social phenomena should be reduced as far as possible to biological terms, just as vital phenomena should be reduced as far as possible to chemical and physical terms" (Preface). "To begin the study of behavior from a biological point of view has, I believe, a very wholesome effect, for it necessitates the use of more or less exact methods of observation which are not always used in psychology and sociology. The use of these methods results in the disappearance of hazy and mystical explanations of human phenomena frequently proposed by writers in these two sciences. These explanations are replaced by more or less exact mechanical explanations" (pp. 2–3). The nature of these mechanical explanations is indicated by the author's method, which seeks to obtain clear concepts of the simpler types of behavior, and then to show how these simpler acts are combined into more complex behavior of a mental and social sort. The method is, therefore, comparative and genetic; and phylogenetic rather than ontogenetic. Tropisms and other reactions of the simplest organisms, reflexes of animals possessing a nervous system, instincts, which are defined as combinations of reflexes integrated by the nervous centers, learning, intelligence, consciousness, society, are successively treated; and some attempt is made to trace the evolutionary process through these increasingly complex modes of behavior. As might be expected, this attempt to trace the phylogenesis of human behavior is not specially successful, on account of the impossibility of selecting a series of animal forms representing the direct line of human descent; and the study is thus, after all, comparative rather than genetic. For example, considerable attention is devoted to the social behavior of insects and of birds, which certainly has no direct bearing on the evolution of human behavior. For the specific purpose of the book, much of this incidental material might well be replaced by something on the growth of behavior in the human individual.

The book is of the Spencerian type, beginning with the characteristics of matter in general, and ending with social evolution. It has required the bringing together of material from various sciences: physics and chemistry, zoology, physiology, psychology, anthropology. One would expect it, accordingly, to be broad rather than notoriously exact; and it is likely to produce the same sort of impression

that is produced by Spencer's work, least satisfactory where the reader knows most about the subjects treated. Certainly under the heads of neurology and psychology, it is somewhat inaccurate and a trifle naïve. The author seems willing almost anywhere to take up a position on questions that are controverted and inherently difficult of decision. Another criticism is that the deductive tendency is more implicitly followed by the author than the nature of his material allows. Once having reached a (perhaps tentative) conclusion on some question, he is satisfied to use this conclusion as the basis of far-reaching deductions. For example, this is his evidence in favor of a richer emotional life in warm-blooded than in cold-blooded animals: "The warm-blooded type developed as a result of the development of the sympathetic nervous system, which regulates the vasomotor system in such a fashion as to keep the body at a uniform temperature by sending blood where more warmth is needed and stimulating the action of the sweat glands where the heat needs to be reduced. I have not the space to discuss the causes for this development here. As we have seen in an earlier chapter, the emotions arise out of the activity of the sympathetic system, so that the development of that system means the development of the emotional nature of these classes of animals. So that the emotions involved in sexual, parental and wider social relationships now begin to play a wider part" (pp. 372–373). It is but fair to say that the author's treatment is much more satisfactory when the broad trend of the book is considered than when particular passages are taken for examination. Certainly it is well to bring emphatically before the reading public the notion that a science of human behavior is possible (and actual, as well, to a much greater degree than this book indicates), and that this science is distinctly a biological science, related to the study of animal behavior, on one side, and on another, to the structure and functions of the nervous system.

R. S. WOODWORTH
COLUMBIA UNIVERSITY

BOTANICAL NOTES

FIGHTING THE CHESTNUT BLIGHT

ONE of the most interesting contests is now being waged between the trained plant pathologists on the one hand and a parasitic fungus on the other, and thus far it must be admitted that the outcome of the battle is by no means as assured as we could wish it to be. The chestnut tree is found naturally in an area stretching from southern Maine to Georgia and Alabama and extending a greater or less distance east and west of the Appalachian Mountains. A few years ago (1904) a disease of the bark of this tree appeared near New York City, and from this point it has spread northeastward, westward and southeastward as far as Massachusetts, Vermont, Central Pennsylvania, Maryland and Virginia. It has been made out that the disease is due to a Sphaeriaceus fungus known as *Diaporthe parasitica,* the structure of which has been pretty well investigated.

So threatening has this disease become that last February a general conference was held in Harrisburg, Pennsylvania, for the consideration of ways and means for preventing its further spread, the results of which appeared a little later in a thick pamphlet of a little more than two hundred and fifty pages of papers, discussions and proposed programs. Many half-tone reproductions of drawings and photographs add greatly to the value of the publication, which must prove to be most useful to the man who wants to try to save his chestnut trees, as well as to the botanist who wishes to keep in touch with this contest between pathological science and a rapidly spreading, disease-producing fungus. As the pamphlet is a state publication it can no doubt be had by application to the governor, at Harrisburg, Pennsylvania.

BOTANICAL NOTES

A HANDY little flora of central and northern Europe has been compiled by F. Hermann, and published by Weigel (Leipzig) under the title of "Flora von Deutschland und Fenno-skandinavien sowie von Island und Spitz-

bergen." It covers the area bounded westwardly by Belgium and eastern France, southerly and easterly by Switzerland, Galacia and central Russia, to the White Sea, Spitzbergen and Iceland. It thus includes Germany, Belgium, Holland, Denmark, Norway, Sweden, more than one half of Russia, besides parts of Austria and France, and the islands mentioned. Yet in spite of the large area included the book contains only 524 small octavo pages. It should serve as a good model for our North American manuals.

Miss Frederica Detmers has published her dissertation for the doctorate, "An Ecological Study of Buckeye Lake," as a contribution to the phytogeography of Ohio, constituting a pamphlet of 138 pages. This artificial lake, a little more than seven miles long, and from a quarter of a mile to a mile and a half in width, was constructed eighty years or more ago on the site of an impassable swamp. Some interesting studies were made by Miss Detmers, and these are recorded in her paper. There is an annotated list of plants collected in and about the lake, and a good bibliography.

The New Jersey Forest Park Reservation Commission has issued a useful pamphlet entitled "The Planting and Care of Shade Trees" which may interest botanists, and certainly will do so for those who are interested in trees. The second half of the book is devoted to "Insects Injurious to Shade Trees," by the state entomologist, J. B. Smith, and "Diseases of Shade and Forest Trees," by the state plant pathologist, M. T. Cook. Many good "half-tone" reproductions of photographs add much to the value of the report.

Allied to the foregoing is the paper on "Cultivation of Native Ornamental Plants," by Miss Eloise Butler, in the October *Minnesota Horticulturist.* In it the author enthusiastically urges the use of a large number of wild plants, listing them under the following heads, Trees, Shrubs, Woody Vines, Herbaceous Vines, Shade Plants, Early Flowering Herbs (chiefly shade plants), Flowering Herbs that will grow in Full Sun. On reading the paper one is filled with a desire to make a little wild garden in one's back yard.

Here we may notice briefly Professor Henry Kraemer's "Outlines of Courses in Botany, Microscopy and Pharmacognosy" for pharmacy students. The "first year's work" (botany) as here outlined is one of the best we have seen.

A dozen years ago Professor Selby, of the Ohio Agricultural Experiment Station, published a bulletin (No. 121) entitled "A Condensed Handbook of Diseases of Cultivated Plants in Ohio," which proved to be so useful that a demand sprang up for it all over the country. Two years ago he published in pamphlet form a revised and enlarged edition (No. 214) under practically the same title, and now we have a bound book with essentially the same matter as the second edition but with the title "Handbook of Diseases of Cultivated Plants." This also is issued by the Experiment Station, and is numbered as before (214). In its present form it is a handy book of somewhat more than one hundred and fifty pages of text and includes one hundred and six text illustrations. We may hope that in time this may grow into a still more complete handbook of plant diseases, the need of which is suggested by the demand shown for this bulletin.

Charles E. Bessey
The University of Nebraska

THE AGE OF PICANTHROPUS ERECTUS

Just twenty years ago Dubois startled the scientific world by his announcement of the discovery of the skeletal remains of an apeman, *Pithecanthropus erectus,* near the hamlet of Trinil in east central Java. The age was supposed to be Pliocene, and recently Dubois has reiterated his belief in the Pliocene age of this unique material, in which he is confirmed by Stremme and others. Discussion of the age of these remains has been the basis for a considerable volume of literature and the recent tendency has been toward considering *Pithecanthropus* younger rather than older. Thus Martin and Elbert assign it to the old

Pleistocene while Volz, Carthaus, etc., consider it middle Pleistocene. The two Selenka expeditions to Java in 1906–07 and 1908 made rather extensive excavations at Trinil and brought back large collections of fossil plants. These have now been described by Schuster,[1] of Munich, and as the results are important the readers of SCIENCE should have their attention called to Schuster's conclusions.

The exposure of the *Pithecanthropus*-schichten at Trinil at the locality where the human remains were found in 1893 is about 25 meters in thickness and consists of interbedded conglomeratic tuffs, lapilli, ash-beds and clays, partially fluvial or lacustrine and probably partly eolian. Plant remains either as leaf-impressions, lignite or petrified wood are scattered throughout the section, occurring most abundantly, however, in stratum No. 6 in the lower half of the section and at the level at which *Pithecanthropus erectus* was found. Eight species of fresh-water gastropods were collected from member No. 4 above the main plant bed, and waterworn bones occur in member No. 5 which is above, and No. 9 which is below, the main plant bed. The main bone stratum, No. 9, contains a meager fauna which is said to show affinities with the Pliocene Siwalik fauna of northern India.

The flora described by Schuster comprises fifty-four species, none of which are extinct, distributed among twenty-two families. The most abundant families are the Moraceæ and Anonaceæ each with eight species, and the Lauraceæ with six species. The geographical distribution of these fifty-four species in the existing flora is somewhat different from what it was at the time of *Pithecanthropus*. Only ten still flourish in the immediate vicinity of Trinil although thirty-two or 62 per cent. are still found on the Island of Java. Twenty-nine or 57 per cent. are mainly Indo-Chinese in the modern flora and one species, *Uvaria zeylanica* of the Anonaceæ, is confined to Malabar, Ceylon and India. Schuster concludes that this flora is of Pleistocene and not Pliocene age, and there can be no question of the correctness of this conclusion, since all the forms are still existing, while in the upper Pliocene flora of Mogi described by Nathorst from this same general region 40 per cent. of the species are extinct. Moreover none of the Pliocene plants described by Crié from Java are present in the present collection. Schuster considers that this Pleistocene flora indicates an annual rainfall of about 400 cm. and a mean temperature of 64 to 68 degrees Fahrenheit. If these deductions are legitimate they show that temperatures were somewhat lower than present-day Javan temperatures, while the rainfall was somewhat greater than it is at the present time. Schuster considers that this Pleistocene flora flourished during a pluvial period which corresponds to the Mindel or second glacial period of Alpine glaciation according to Penck's nomenclature, and that *Pithecanthropus erectus* is slightly older than *Homo heidelbergensis* discovered in 1907 by Schoetensack at Mauer near Heidelberg, Germany. Just how this exact correlation is reached it is difficult to understand; in fact I hardly see how there can be any reliable data for such a long range correlation. It seems to me that the exact stage in the Pleistocene is undeterminable. According to Schuster's correlation the age is lower middle Pleistocene, although he calls it old Pleistocene. In the temperate zone a fossil flora with no extinct species indicates a late middle or upper Pleistocene age, but very likely this does not apply with equal force to tropical regions where the physical conditions have been more uniform than in the temperate zone.

The three largest of the Sunda Islands—Java, Borneo and Sumatra—are separated from the Indo-Chinese mainland and from each other by shallow seas less than one hundred fathoms in depth and for the most part not deeper than fifty fathoms. These seas date from the submergence in the late Pleistocene. In spite of this fact and the further fact that the mountain axis of Sumatra also

[1] Schuster, "Monographie der fossilen Flora der Pithecanthropus-Schichten," *Abh. k. Bayer. Akad. Wiss., math.-physik. Klasse*, 26 Band, 6 Abhandl., 1911.

forms the backbone of Java, the intervening Sunda Strait being only fifteen miles across, the existing flora and fauna of Java are less like those of Sumatra than those of the latter are like those of Borneo. The biota of Java is, on the other hand, much more like that of the Siamese peninsula and northern India, and it is very interesting to find similar and apparently anomalous affinities shown as long ago as the Pleistocene and certainly before the submergence which gave the region its present physical geography.

Edward W. Berry
Johns Hopkins University

SPECIAL ARTICLES

SOME RELATIONS BETWEEN ROOT CHARACTERS, GROUND WATER AND SPECIES DISTRIBUTION

Observations on the root habits of desert shrubs indicate that the root-type of any species may be of importance in limiting the distribution of the species. This has been found to be especially clear in the case of plants having obligate tap roots, which, as a rule, are confined to relatively deep soils. Such shrubs as have a generalized root-system, on the other hand, have a wide local distribution, which may be correlated with the fact that the roots of these plants are capable of a large degree of modification in conformity with the pressure of the soil environment. But the rôle of the superficial type of roots, such as is typical of species with water storage capacity, is not so well defined. It is known that the fleshy cacti, for example, are most highly developed where the rainfall is a periodic one, occurring, perhaps, twice each year, but that these plants occur sparsely where the precipitation takes place once annually. Whatever may be the reason for this limitation, it is noteworthy that the larger mass of absorbing roots of species having a water balance lie within 10 cm. of the surface of the ground. The superficial soil layer is subject to the most intense desiccation, and, hence, carries moisture in sufficient amount for the use of plants for the shortest period only, so that plants depending on this stratum for moisture must either be short-lived or have the capacity of storing up water against the following period of drought. What the minimum absorption time of fleshy plants is, has probably not been determined, but it is evident, from their distribution, that the amount of available moisture in the superficial soils derived from a single rainy season each year is not sufficient. To put the case in another way, it is apparent that the general and local distribution of the fleshy cacti would be other than it now is, if such plants had another type of root-system, for instance, if there was an obligate deeply penetrating root-system, in place of the superficial one they now have. Such a change, were it possible, would, in the first place, limit the local distribution to flood plains or to other areas having deep soil, and, in the second place, it would permit a wider general distribution. This suggestion makes it evident that the root-soil moisture relation may be an important factor among those which determine the survival of a species.

Such observations as have been made on the root habits of trees indicate that in these large-bodied plants the root character may also be of importance among the factors which operate to influence their distribution.

It is now well established, at least for a portion of the Southwest, that there may be a very intimate relation between the occurrence of certain species of trees and the character of their roots, having regard to the depth at which perennial water may be found. Here trees occur along streamways, while the near-by upland may be treeless. The humidity of the two areas may not be very unlike, nor the rainfall, nor yet the temperature. The great difference, which is often striking, lies mainly in the soil conditions, particularly with regard to the depth to the ground water. On the bottoms the water table lies within reach of the roots of trees, while on the more elevated land it is far below them.

The depth to the level of ground water, or to the soil that is moistened from the water table, is usually not great. In the eastern portion of the United States, in lands of mod-

erate elevation, water can commonly be obtained within 30–40 feet of the surface, while in the valleys the water lies at a depth of 15 feet, or less.[1] In the states of the middle west, as in Kansas and Nebraska, according to various sources, mainly the Geological Survey, the depth to ground water on the flood plains of streams varies from 10 to 40 feet, but the depth on the benches, valley sides and upland is from 60 to several hundred feet. A like condition is to be found in the more arid regions further west, while the more humid regions of the extreme West are similar, as regards depth to the water table, to the humid east. In rough and mountainous regions, the water reservoirs of whatever kind may be regarded as the physical equivalents of the water table of the more level country, and provide such plants, especially the trees, as penetrate to them, or to the soil moistened by them, with a perennial supply of water.

The various physical factors, climatic as well as those pertaining to the soil, which influence the distance to ground water, are, in the main, of significance in the physiological activities of the trees occupying an area. And, in addition to such factors, appropriate temperatures being assumed, the specific responses of trees to the water relation are to be considered. Chief among these are the water-retaining and water-absorbing capacities and adjustments, of which the root-ground water relation must be considered to be of great importance.

The general relations of trees to perennially moist soil, as indicated by the depth of the water table and by the distribution of trees and forests, and taken from a few widely separated regions, may be illustrated by a few examples.

In southern Arizona, in the vicinity of the Desert Laboratory, the distance to the water table, or to perennial ground water, is various. On the bajada, water is to be obtained at a depth of 70 feet, or over, while on the flood plains of the streams it lies from 15 to 35 feet beneath the surface. There is practically no arboreal flora on the bajada, but along the streams, and on their flood plains, occur ash, cottonwood and mesquite, the latter often forming an open forest of trees ranging as high as 40 feet, or more. The mesquite may be taken to illustrate the relation between trees of the vicinity and the depth to perennial water supply.

The mesquite is the most widely distributed tree of the Tucson region, occurring not only on the flood plains of streams, but on the higher bajada as well. The form of the species, however, when growing in such diverse habitats is quite unlike, since apart from the flood plains it assumes the form, not of a tree, but of a shrub. There is a close association between the dual habit of the mesquite as noted and the depth to the water table, which is also shown by a variation in the development of its roots.

The root-system of the mesquite is an extremely variable one. It may penetrate the ground deeply, or it may extend widely and lie not far beneath the surface of the ground, or, again, it may be of rather limited extent and of a generalized character. The first type of root is probably most characteristic of the tree form, and the last of the shrub form of the species, while the second arrangement may be connected either with the tree or the shrub habit. On the flood plain, roots of the mesquite as a tree have been seen to penetrate to a depth of 15–24 feet, or to the level of the water table. Under especially favorable soil conditions, as where it is fairly homogeneous and easily penetrable, the roots may attain a greater depth.

A comparison of the distribution of the tree form of the mesquite with maps which give the water table depths indicate that the species becomes a tree, soil conditions favoring, where the ground water does not lie deeper than 50 feet. On the other hand, where the water table is at a greater distance, or is otherwise not available, the shrub habit is assumed, with characteristic generalized root-system.

[1] Crider and Johnson, "Water Resources of Mississippi," U. S. Geological Survey, Water-Supply and Irrigation Paper No. 159, 1906.

An extension of observations on tree distribution, as related to the depth of perennial water, to regions outside of southern Arizona, gives interesting, if not entirely conclusive, results. A comparison of the depth to ground water of the Coastal Plain of Texas, as given by Taylor,[2] with the tree distribution, as given by Bray,[3] for example, offers important suggestions in the present connection. In general, it may be said, that the stream bottoms of the Coastal Plain support a hardwood forest, which also extends over such upland as has a fairly shallowly placed water table. Such of the deciduous trees as are marked xerophytes, for example, the post oak, occur on dry ridges where pines of various sorts are also to be found, and where the depth to permanent water is considerable. Of these trees, the root habit of the long-leaf pine is known. This species has a long tap root which penetrates to a great depth and which renders the species in a measure independent of surface conditions of soil and moisture. In the more arid southern portions of the Coastal Plain, where the water table lies below 50 feet, chaparral is characteristic of the upland, and, along the streams, where the water table is less deep, forests occur.

Northward from Texas, as well as westward from the Coastal Plain of the state, are to be found conditions analogous to much already noted for southern Arizona and the Coastal Plain. That is, other things being equal, trees and forests, especially deciduous forests, are limited to areas where the depth to the water table is not great. Thus, in Kansas and Nebraska, the deciduous forests are mostly confined to the flood plains of streams, while the adjacent upland is treeless.

As one examines other regions (reference is made more in particular to those that are semi-arid) he finds forests confined to such areas as are underlain by ground water not beyond the attainment by the roots of trees.

[2] U. S. Geological Survey, Water-Supply and Irrigation Paper No. 190, 1907.

[3] U. S. Dept. Agric., Bureau of Forestry, Bull. No. 47, 1904.

Although it is not practicable at present to give in detail the relation of tree roots to the water table in the more humid regions, enough is known to justify the belief that often there is a very intimate relation between the two, according to Bowman.[4] For example, the level of the ground water is said always to be lower in a forested tract. The same writer states that the greater supply of moisture for trees is derived from deeper lying sources, *i. e.*, than which supplies shallowly rooted plants. The roots, also, which supply the moisture, descend to a point a little above the surface of the ground water. If the level of the water table changes greatly, the trees suffer either from lack of moisture, or from poor aeration, according as it is lowered or raised. The variation in depth to the ground water, however, does not affect trees having superficial roots, or at least roots which do not attain it, and such species are well adapted for growth where the water table is high, or the upper soil is shallow. The ecological importance of this is apparent, and may be illustrated by a single example. Rossmässler[5] mentions trees which are characteristic of two habitats, of which one is rough and stony, and the other is underlaid by an impervious clay. Oaks and pines form a mixed forest in the first habitat, and of these the oaks at least have deeply penetrating root-systems. In the second habitat there is only *Picea,* since the soil depth prevents such root development as is characteristic of the other species.

An important phase of the study of the relation of roots to the water table lies in observing the range of variation under natural conditions. Specialized roots, such, for example, as were mentioned at the beginning of this note, are, generally speaking, not capable of great variation. Hence, plants with this character of a root-system, and for this reason only, may have sharp bounds placed on their distribution. On the other hand, generalized root-systems are often variable to a high degree, and, corresponding to this fact,

[4] "Forest Physiography," p. 42, etc., 1911.

[5] "Der Walde," p. 31, 1881.

the species bearing generalized roots may have a relatively wide distribution, occurring in widely different habitats. Cowles[6] gives an interesting example of the relation between root variation and species range. The red maple grows in swamps and also on dry grounds. The root character of the tree on the two habitats is very unlike. In the swamps the tap root is not largely developed, but the laterals are prominent, while in the dry situation the reverse is the case, the tap root being the leading characteristic of the root-system.

The problems which deal with the presence of trees are primarily physiological and have mainly to do with the absorption and conservation of water. Each of these capacities varies with the species. Of the root relations that of the root-water table is of prime importance, owing to the fact that the soil horizon, tapped by the roots of trees, derives, by capillarity, from the level of ground water, its perennial supply of moisture. In the semi-arid regions probably the roots of most trees attain to the perennially moist soil, sometimes to the water table itself, at least for a portion of the year, and, in the more humid regions, the roots frequently do so. In both regions, certainly in the former, wherever such is not the case, a variety of factors, which need not be discussed in this place, are of greater importance in the survival of the species than the water table depth, although the character of the root-systems may still be of much, possibly of definitive, importance.

W. A. CANNON
DESERT LABORATORY

INORGANIC COLLOIDS AND PROTOPLASM[1]

BREDIG[2] has shown that inorganic colloidal solutions, such as silver, platinum and gold, may act as catalyzers in certain chemical reactions, such as the reduction of hydrogen peroxide to water, and while chemists have studied the problem of the action of catalyzers from this standpoint, biologists have signally avoided attempts[3] to determine whether the activities of the enzymes of the organism can be imitated by these inorganic catalyzers. It must be remembered in any such examination that, as Ostwald[4] has demonstrated, along with others, enzymes of any nature are incapable of instigating a reaction, but their function is solely that of modifying the Guldberg-Waage mass action equation for a given instance, either accelerating or retarding a reaction already in progress. Therefore, we should not expect to find a striking modification of the actions or of the structure of any organism, if any effect were obtained by the application of inorganic "enzymes."

In a series of experiments, I attempted to determine whether colloidal platinum and a colloidal gutta percha[5] gave evidence of any effect upon simple organisms, such as protozoa and single-celled plants. Platinum black was obtained by the use of the house current, reduced to about 70 volts, passing it through a lamp-board, the current delivered to water which had been glass-distilled, the electrodes being of platinum, according to the Bredig method.[6] In order to be certain that the solution was desirable for experimentation, it was examined over a Zeiss dark-ground con-

[6] "Text-book of Botany," Vol. 2, Ecology, p. 506.

[1] Presented in abstract form to the Columbia University Biochemical Association and outlined in the *Biochemical Bulletin*, II., 1, 1912.

[2] "Anorganische Fermente," Leipzig, 1901.

[3] Benj. Moore (in "Recent Advances in Physiology and Biochemistry." L. Hill, Edt. London: Edward Arnold, 1908; Chapter 4, p. 122) mentioned having performed injection experiments with platinum sol on animals, but he gives no details; he obtained negative results. Autolysis has been shown to become accelerated under the influence of colloidal metals. (See Ascoli and Izar, *Biochem. Zeitschr.*, Bde. 5, 7, 10, 14 and 17; also Doerr, same journal, Bd. 7.)

[4] "Uber Katalyse," *Vortrag auf d. Ges. d. Naturf. u. Arzte*, 1901.

[5] Professor Henry A. Perkins, of the Jarvis Physical Laboratories, Trinity College, prepared this solution after the formula which he used in the laboratory of Professor Perrin at the Sorbonne, and I am indebted to him for the kindness.

[6] *Zeitschr. f. angew. Chemie*, 1898, p. 951.

denser, but no attempt at ultra-filtration, which might easily have been done by using collodion as Schoep[7] has done, was made, for I was not concerned in these experiments with the size of the particles. The solutions were found to be quite active and little or no deposit of the coagulated platinum ["sponge"] was obtained, which, of course, is not active catalytically to the extent to which platinum black is. I have tried colloidal iron in somewhat similar experiments, but it is assuredly not to be expected that this colloid would give results with living things, on account of its low activity as an inorganic catalyzer. The gutta percha was dissolved in ether and emulsified by water and alcohol, and then the whole mass was dialized through fish-bladder for three months to remove the alcohol and ether. It was examined before using, to determine the activity as far as the Brownian movement could be taken as a criterion.

Paramecium, Stentor, Blepharisma, Euglena, Phacus and diatoms, *Ceratium* and other desmids were used as material, but more exact work was done with *Paramecium* and *Stentor*. One set of experiments consisted in isolating individuals of these species and making drop-cultures of them in a small amount of the colloidal solution; a second series was conducted in salt dishes, where the amount of colloidal solution was about 2 cm^3. I ran checks with tap-water.

It was to be expected that the platinum solution, at any rate, would prove to be toxic, but this was not the case, for the organisms lived without any suggestion of being in an unwholesome medium; the same was true for the gutta-percha solution. The rate of cell-division was noted, comparing that of the individuals under experimentation with that of the checks. The rate was found to vary in no appreciable manner. One variable may have been introduced, and that was food, but I could not devise any way of eliminating the difficulty. Bacteria were present in all of the solutions and, of course, in the medium of the control experiments. The bacteria were kept down appreciably by keeping the dishes in strong light, but this did not eliminate them.

From these experiments, which are by no means exhaustive, I conclude that the inorganic catalyzers, such as I have used, are not effective in appreciable manner on protoplasm. It may well be that protozoa are not affected, while other organisms, or portions of other organisms, may be. As an instance where protozoa are not affected by an agent that is markedly effective in inducing cell-division in certain tissues in higher forms, I may mention the power of certain azo-compounds, notably Scharlach R, to cause proliferation of epithelium in mammals, so that they have been introduced into dermatology for treatment of burns on the skin, and it has been noticed that workers in anilin factories[8] show thickenings of the skin caused by contact with the dyes. I have grown *Paramecium* in drop-cultures with granules of Scharlach R, which were seen to enter the bodies of the organisms and to occur in the food vacuoles, but there was no evident increase either in the size of the organisms or in their rate of fission. Obviously, the dye is not responded to by protozoa as it is by epithelium; perhaps this specific response is somewhat similar to conditions in experiments with inorganic catalyzers. In these experiments, both a suspensoid [colloidal Pl and an emulsoid [gutta percha] were used. It is to be remembered that the study of inorganic catalyzers has been carried on principally with the latter group, but this does not mean that the former one is not promising, or for *a priori* reasons should not be expected to give results, except in so far as it does not follow the criterion of Emil Fischer[9] of a stereochemical relation, wherein enzymes of whatever nature are defined as optically active catalyzers; platinum black is not optically active, which may account for its inability to influence organisms. The same may be said of the gutta-percha solution.

P. S.—Since the above account of my experiments was written, there has appeared a very

[7] "Über ein neues Ultrafilter. Wo. Ostwald's Kolloid-Zeitschr.," Bd. 8, p. 80, 1911.

[8] See Sachs, *Wien. klin. Wochenschr.*, Bd. 24.

[9] *Chem. Ber.*, Bd. 27, S. 3230.

interesting communication from the Barnard Skin and Cancer Hospital in which Dr. Leo Loeb describes experiments with colloidal copper, derived by the Bredig method, upon neoplasmic growths; he finds that intravenous injections cause cessation and absorption of the cancerous tissue.

MAX MORSE

TRINITY COLLEGE,
October 25, 1912

SOCIETIES AND ACADEMIES

THE AMERICAN PHILOSOPHICAL SOCIETY

AT a meeting of the society on February 7 Dr. Paul Heyl presented a paper on "Platinum in North Carolina." A belt of platinum-bearing rock runs from Danville, Va., to Cedar Falls, N. C., a distance of some seventy miles. Assays of as much as 4 or even 8 ounces per ton are occasionally found, but the average content is too small to be commercially important. The platinum in the rock is very rich in iridium. The deposit has been known for about seventeen years. An examination of the watershed of the region for 200 miles from the center for placers yielded negative results.

On March 7 the following paper was presented: "A Historical Account of the Early Microscopical Studies in the Structure of Animals and Plants with Reference to the Development of the Cell Theory," illustrated by lantern slides, by R. M. Pearce, professor of research medicine, University of Pennsylvania.

A sketch of the work of Hooke, Malpighi, Grew, Swammerdam and Leeuwenhoek in the last third of the seventeenth century, with remarks on the early microscopes, followed by the story of the development of our knowledge of plant and animal structure, as Lieberkuhn's (1739–48) studies of the finer structure of animal tissue, Trembly's (1744–47) observations on the division of protozoa, Brown's (1833) description of the nucleus and Treviranus's (1806) and Mohl's (1828) studies of the vegetable cell. A discussion of the improvements in the microscope up to 1830 and of the fundamental observations of Schleiden (1838) and Schwann (1839) which, followed by those of Virchow (1858), definitely established the cell theory. A short discussion of later work on the nature of cell protoplasm (Dujardin, Schultze) and the study of the nucleus and the process of division of cells, concluding with Flemming's observations in 1882. Illustrated by lantern slides showing many of the original drawings which accompanied the reports of the various fundamental observations.

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 33d annual meeting was held in the hall of the Cosmos Club, December 14, 1912, with Vice-president W. P. Hay in the chair. Reports of officers for the year 1912 were received and the annual election of officers took place. The election resulted as follows:

President—E. W. Nelson.

Vice-presidents—J. N. Rose, Paul Bartsch, W. P. Hay, A. D. Hopkins.

Recording Secretary—D. E. Lantz.

Corresponding Secretary—N. Hollister.

Members of Council—Hugh M. Smith, Vernon Bailey, Wm. Palmer, A. B. Baker and A. K. Fisher.

THE 505th regular meeting was held January 11, 1913, with President E. W. Nelson in the chair and 54 persons present. The chairman appointed standing committees on publications and communications for the year.

C. V. Piper exhibited a vase made of wood and covered with a thin veneer of "silk-wood." This veneer is cut from one of the large *Polyporus* fungi and takes a beautiful polish.

A. S. Hitchcock and E. W. Nelson each reported his recent return from a successful collecting trip, the former having collected grasses in Jamaica, Trinidad and Tobago, while the latter had secured birds and mammals in Arizona.

The regular program consisted of three communications:

The Rediscovery of Œnothera grandiflora: S. M. TRACY.

The speaker gave an account of two trips made by him to the locality of Bartram's original discovery of this species (1776). The locality is near Dixie Landing, Alabama, and the flower described by Bartram was found abundant over a limited area. A second visit was made last year in company with Dr. Hugo de Vries.

The Problem of the Identity of Œnothera Lamarckiana: H. H. BARTLETT.

The speaker gave a history of various cultivated strains of plants of this species and its hybrids. He predicted that its original habitat and identity —as yet unknown—would eventually be discovered, probably in America south of the United States and on the Pacific Slope.

Sawflies and their Relations to Forestry: S. A. Rohwer.

These very destructive insects were classed as defoliators and wood borers, and many instances of serious damage by them to growing timber were given. The paper was illustrated by numerous lantern slides showing various species of sawflies —adults, pupæ and larvæ—and also illustrations of damaged timber.

The 506th regular meeting was held January 25, 1913, with the president in the chair and 47 persons present.

The following resolution relating to zoological nomenclature was presented to the society with the endorsement of the council and adopted unanimously:

Whereas certain zoologists have gone on record as favoring

1. A permanent and increasing list of exceptions to the law of priority,

2. A return to the principle of elimination regardless of the generic types that have been designated under the rules, and

3. A rejection of the present unanimous vote rule that has obtained for so many years in the International Congress on Zoological Nomenclature.

Therefore, be it resolved by the Biological Society of Washington that we favor

1. The consistent application of the law of priority in all cases,

2. The acceptance of the first designation of a genotype, regardless of the method followed in designating it, and

3. The present unanimous vote rule as making for conservation and stability in nomenclature.

Under the heading Brief Notes, etc., Paul Bartsch exhibited a small photographic camera, with a number of small pictures made with it and enlargements of the same. He spoke briefly of its convenience and adaptability to field uses.

Barton W. Evermann reported that a wireless message had just been received from Agent Lembkey at the Pribilof Islands in which it was stated that the reindeer herds on St. Paul and St. George had increased during the past year from 37 to 65 animals and that all are in excellent condition.

The regular program consisted of two communications:

Notes on the Biology of the Common Termites of the Eastern United States: Thomas E. Snyder.

This paper was illustrated by many lantern slides and was discussed by E. A. Schwarz.

The Biting Powers of Ants: W. L. McAtee.

The speaker's personal observations as well as instances gathered from many sources were cited to show the powers of these small animals. Messrs. E. A. Schwarz, A. C. Weed, A. D. Hopkins and the author of the paper took part in the discussion which followed.

The 507th regular meeting was held February 8, with President Nelson in the chair and 57 persons present.

Professor Burt G. Wilder gave an illustrated lecture on "The Brain as a Guide to the Affinities of Vertebrates," basing his remarks primarily on the brain of the shark *Pentanchus* recently described by Smith and Radcliffe as the type of a new family. The speaker showed by means of diagrams the evolution of the selachian brain from the most primitive form found in *Chlamydoselachus* through the other Notidani to the typical sharks; and announced his conclusion, from the evidence afforded by the brain, that *Pentanchus* is not a notidanid. He did not venture, however, to say just what the systematic position of this shark may be until the vertebræ and intestine have been studied, although it is certainly not related to the Scylliorhinidæ, to which Regan[1] assigns it on the theory that the single dorsal fin is an abnormality.

In the discussion which followed, H. M. Smith said that in assigning *Pentanchus* to the order of ancient sharks, partly on account of the single dorsal fin, he and Mr. Radcliffe had been aware of characters in which this shark differs from typical Diplospondyli, but that no other course seemed expedient at the time the preliminary description was published. The vertebræ, while not diplospondylous, but modified cyclospondylous, are of a very primitive type, being only half the size of those in a scylliorhinid shark of the same length, with an extremely small centrum and a very large neural canal.

Theodore Gill discussed the subject at length, and agreed with Professor Wilder in attaching great taxonomic importance to the brain in sharks and rays. He had concurred in the assignment of *Pentanchus* to the Notidani, and now regarded it as the type of a peculiar family whose affinities remain to be determined.

D. E. Lantz,
Recording Secretary

[1] Science, July 19, 1912.